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The Macrofauna of the Surf Zone Off Folly Beach, South Carolina

William D. Anderson, Jr., James K. Dias,
Robert K. Dias, David M. Cupka,
and Norman A. Chamberlain

January 1977

U.S. DEPARTMENT OF COMMERCE
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U.S. DEPARTMENT OF COMMERCE
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The Macrofauna of the Surf Zone Off Folly Beach, South Carolina[1]

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ABSTRACT

A seining survey of the macrofauna of the surf zone at Folly Beach, Charleston County, S.C., was conducted from October 1969 to October 1971. Eighty-seven collections were made in the surf and associated tidal pool resulting in the capture of 512 specimens of swimming invertebrates representing at least 17 species and 5,095 specimens of bony fishes representing 41 species.

The data obtained are analyzed on seasonal and yearly bases for total weights and numbers of species and specimens. Species are ranked as to importance; and prediction equations for monthly average number of specimens per collection in the surf, based on environmental variables, are developed. Length-frequency data and other aspects of the biology of selected species are presented. Length-length and length-weight relationships are given for certain species. Recommendations for the improvement of the methodology for similar surveys are made.

INTRODUCTION

Although the taxonomy of the fishes and many of the larger invertebrates inhabiting the inshore waters and estuaries of South Carolina is reasonably well known, the life histories of many of these species are incompletely known—data on the larvae and juveniles and on the seasonal variations and fluctuations of populations being especially limited. This study was initiated with the intent of filling part of this gap in our knowledge of the surf zone.

In several studies since 1940, the ichthyofauna of the surf zone has been surveyed along the Gulf and Atlantic coasts of the United States [e.g., Gunter (1945, 1958) and McFarland (1963) in Texas; Springer and Woodburn (1960) in the Tampa Bay area; Miller and Jorgenson (1969) and Dahlberg (1972) in Georgia; Cupka (1972) in South Carolina; Tagatz and Dudley (1961) in North Carolina; and Schaefer (1967) in New York], but to our knowledge no surveys have been conducted on a regular year-around basis north of North Carolina in the surf zone of unprotected beaches.

Of the many shore habitats, the surf zone of exposed beaches has been least studied. Part of the paucity of data on the surf zone is certainly due to the difficulties inherent in collecting in it. It is unfortunate that our knowledge of this environment is so meager because this rather extensive and physically well-defined habitat is not only economically important as a recreational area for sport fishermen, but also is significant as nursery grounds for certain commercial and sport species such as the pompanos, *Trachinotus* spp., mullets, *Mugil* spp., and Gulf kingfish, *Menticirrhus littoralis*. Other species inhabiting the surf undoubtedly prey upon or form a significant part of the diet of a number of economically important species. In order to adequately understand the ecology of the surf zone, basic data on the composition and seasonal variations and fluctuations of populations of both resident and transient species are necessary. With the preceding in mind, a 2-yr biweekly seining survey was initiated at Folly Beach in October 1969. A short abstract of the first year of this study was presented by Anderson et al. (1971).

DESCRIPTION OF THE STATION

Folly Beach (on Folly Island, a barrier island) is about 14 km south of the Charleston peninsula in Charleston County, S.C. The littoral zone at this beach is a high-energy environment, unprotected from the force of the open Atlantic Ocean by any physiographic feature. Collections were made in the surf (i.e., the breakers and slightly seaward) and tidal pool (when present) between the last two groins at the southwestern end of the beach (lat. 32°38.7′N, long. 79°57.6′W). The beach slopes gently in this area (about 1-1½%) and is predominantly sandy (fine sand), although considerable shell and larger shell fragments were present on about one-half of the collecting days. Tidal ranges are 5.2 feet (1.58 m) mean and 6.1 feet (1.86 m) spring. The height of the sea varied from about 0.2 to 2.1 m ($\bar{x}$ = 0.6 m).

A tidal pool[6] was present on approximately 70% of the collecting days. Its dimensions varied considerably from one collection to the next. On several occasions it was limited to a small pool at the seaward end of one (or of each) groin and on others was a very long trough in excess of 200 m in length. Because the groins (of timber pilings) were well covered with encrusting invertebrates and because the currents tended to scour out the areas at the seaward ends of the groins, these man-made structures acted as unnatural foci for the concentration of motile animals. Despite this the presence of the groins affected only the catch in the tidal pool, because at the times we made the surf collections the tide had receded beyond the groins.

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[6] A "tidal pool" is "A pool of water remaining on a beach or reef after recession of the tide" (Howell 1960).

The minimum and maximum water temperatures observed were: surf, 6.4° and 28.6°C; tidal pool, 3.7° and 26.8°C. The salinities in the surf ranged from 23.2 to 35.0°/oo; those in the tidal pool, from 25.8 to 33.4°/oo. (For data on temperature and salinity, see Tables 1 and 2.) The lowest salinities were recorded after heavy local rains. Because the collections were made near the time of predicted low water, the maximum diluting effect of the groundwater was manifest.

MATERIALS AND METHODS

Collecting and Handling Specimens and Data

Collections were made by seine at approximately biweekly intervals (from 11 October 1969 to 10 October 1971) in the surf and tidal pool (when present) near the time of predicted low water. All except three of the collections were made in the morning (0500-1130 EST). The time required to make a collection varied from 5 to 40 min ($\bar{x}$ = 15.4) in the surf and from 1 to 25 min ($\bar{x}$ = 10.3) in the tidal pool.

The surf was seined with a 19.8- by 1.8-m, 9-mm stretch-mesh nylon bag seine with bag opening of 1.8 m in diameter and length of 1.8 m. Initially, the tidal-pool collections were made with the 19.8-m seine—later (because of ease of handling) with a 7.1- by 1.6-m, 9-mm stretch-mesh nylon bag seine with bag opening of 1.8 m in diameter and length of 1.8 m. Except when beaching and when collecting in the tidal pool was restricted to small pools at the groins, the seines were pulled parallel to the beach.

In the surf, the seine was pulled approximately 185 m, the distance between the groins. During almost all of the first year, two hauls, each about one-half the distance between the groins, were made—the first haul starting opposite one groin, the second terminating opposite the other. Later each surf collection was made with a single tow. Generally, the seine was towed with the longshore current which usually ran from northeast to southwest. The distance seined and the number of hauls in the tidal pool varied with the length and configuration of the pool, but never exceeded 185 m. The use of seines of different lengths did not affect the catch in the tidal pool because even the smaller seine was long enough to reach across the width of the pool. There were no duplicate or reciprocal tows in either the surf or tidal pool, i.e., a given area was seined only once per collecting trip. Assuming that the opening of the seine was 12 m (±2 m), the area covered in a seine haul between the groins in the surf was about 2,220 m^2. Surf and tidal-pool catches made on the same day were considered as different collections and were handled separately. Air and water temperatures, salinity, and turbidity were measured and observations were made on the condition of the sea, height of the breakers, wind velocity and direction, cloud cover, character of the bottom, and depth of water seined.

All material was measured and weighed after preservation. Standard length (SL), fork length (FL)—when applicable, total length (TL), and weight (W) of each fish were taken. Specimens were thoroughly blotted externally and excess moisture was squeezed out of the gill chambers of fishes before weighing. Similar techniques were used for invertebrates except that carapace length (CL) and width (CW) were measured on crabs.

Data were coded for input on 80-column Hollerith code punch cards. Four types of cards were used for each collection: 1) location data card, 2) physical data card, 3) species data card (number of specimens, total weight, and length and weight ranges), and 4) specimen data card (scientific name, sex if determined, lengths, weight, and miscellaneous data as appropriate). Data were analyzed on an IBM System 360/40 DOS computer. The software used for the analyses of the data was the Dynamic Computer Systems/Multi-purpose Information Processor and the UCLA BMD, Biomedical Computer Programs.

In this study we define the seasons as follows: October, November, December—Fall; January, February, March—Winter; April, May, June—Spring; and July, August, September—Summer.

Selectivity of Collecting Method

The method of collecting used in this study was highly selective. The material that could be collected by seining was determined by the characteristics of the net (length, configuration, and mesh size), certain environmental factors, and the speed at which the net could be pulled, which is largely a reflection of environmental conditions. In the surf the environmental factors with the greatest effects were velocity of longshore current, condition and height of sea, nature of bottom, temperature, and turbidity; in the tidal pool those of greatest importance were conditions prevailing at the previous flood tide and the configuration of the pool itself which was a product of the conditions existing at the time of formation.

In the surf large individuals were not as readily collected as smaller ones; however, at times of low water temperatures the motility of larger animals was reduced greatly, thereby decreasing their chances of escaping capture. Individuals less than a certain critical size (a function of mesh size) were not retained in the net unless they became entrapped with other animals and debris in the bag of the seine.

The seine was usually pulled with the longshore current because most frequently it was impossible to make headway against it. Even though our hauls were for the most part with the current, the time required to cover the distance between the groins varied considerably because of differences in current velocity. Our catch, then, was affected both qualitatively and quantitatively to unknown degrees by variations in the current.

In the tidal pool all individuals greater than a certain critical size would appear to be captured with ease. However, experience showed that this was not the case. Due to the configuration of the tidal pool, particularly when it was in part or entirely associated with one (or both) of the groins, animals were seen that were not collected.

RESULTS AND DISCUSSION

Collections

A total of 87 collections were made, 51 in the surf (Table 1) and 36 in the tidal pool (Table 2). Each collection in the surf yielded at least one species of fish (1-9) and all but 14 at least one swimming invertebrate species (1-6). Twenty-eight of the 36 collections in the tidal pool produced at least one species of fish (1-7), but swimming invertebrates (one species) were obtained in only eight collections. The total number of species of fishes and swimming invertebrates varied from 1 to 13 per collection in the surf and 0 to 7 in the tidal pool.

The number of fishes per collection in the surf varied from 2 to 310; the number of swimming invertebrates from 0 to 79. In the tidal pool the number of fishes per collection ranged from 0 to 759; the number of swimming invertebrates from 0 to 12. The total number of specimens of fishes and swimming invertebrates ranged from 2 to 311 per station in the surf and 0 to 759 in the tidal pool.

The weight of fishes per collection in the surf varied from 7 to 2,045 g, that of swimming invertebrates from 0 to 655 g. The weight of fishes per collection in the tidal pool varied from 0 to 817 g, that of swimming invertebrates from 0 to 7 g. The total weight of fishes and swimming invertebrates varied from 7 to 2,047 g per station in the surf, and from 0 to 817 g in the tidal pool.

Some 512 specimens of swimming invertebrates representing 4 phyla, 4 classes, 6 orders, 11 families, about 15 genera, and at least 17 species; and 5,095 specimens of bony fishes representing 7 orders, 19 families, 32 genera, and 41 species were collected and examined during this study. About 350 specimens representing at least 32 additional species of invertebrates were also collected. This group of species included nonswimming motile forms characteristic of calmer offshore waters, unattached bottom-dwellers of the surf zone (such as pelecypods and echinoderms), and detached offshore sessile organisms. Seventeen of these species (represented by 102 specimens) were collected only on 16 July 1971 shortly after a tropical storm passed near the coast of South Carolina. Because these 32 additional species of invertebrates are not ordinarily found in the surf zone or are bottom-dwellers not adequately sampled by our method of collection, they are not considered further.

Sixteen of the 17 species of swimming invertebrates were found in the surf, but only five were found in the tidal pool. Nearly all of the specimens (491 of 512) and nearly all of the mass of swimming invertebrates (4,291 of 4,300 g) were found in the surf.

All 41 species of fishes collected were found in the surf, but only 16 appeared in the tidal pool. Approximately 54% of the specimens (2,747) were seined in the surf and about 46% (2,348) in the tidal pool. Approximately 74% (12,866 g) of the ichthyomass was caught in the surf and about 26% (4,452 g) in the tidal pool. The mean weight of fishes from the surf was more than twice the mean weight of those from the tidal pool (4.68 to 1.90 g). Larger fishes tend to avoid being trapped in shallow tidal pools as the tide ebbs, whereas smaller individuals may find refuge in these relatively predator-free pools. It is conceivable that these transient pools provide havens that are important to the survival of the fry of species such as *Trachinotus carolinus* and *Mugil curema* and to individuals of most size ranges of *Fundulus majalis* and *Menidia menidia*. Individuals of the latter two species may seek these quiet waters for feeding. Although one of the effects of fishes concentrating in a tidal pool is to make them more vulnerable to some piscivorous birds, the advantages of temporary residence in an isolated pool (protection from predatory fishes and certain birds and the availability of food) may far outweigh this disadvantage. Of the most important species, the fishes *Anchoa mitchilli* and *Menticirrhus littoralis* and the decapod crustacean *Arenaeus cribrarius* were collected almost exclusively in the surf, while the fish *Fundulus majalis* was caught almost entirely in the tidal pool. Table 3 presents summaries of data on collections, size ranges, total weights, temperature, and salinity for fishes and *Arenaeus cribrarius*, and Table 4 presents the monthly size range and number collected per month for fishes and *A. cribrarius*. In both tables *A. cribrarius* is included because it was the only invertebrate species collected in sufficient numbers for analysis. Data on the other swimming invertebrates collected are presented in Table 5.

The numbers of specimens collected were quite small compared with those of some surveys. Our small catches resulted from the difficulties encountered in collecting in the surf and the limitations imposed by our sampling procedure (the absence of replicate tows and collecting sites and the use of a small beach seine). The similarities in the two years in the compositions of the collections and the seasonal trends indicate that our methodology was adequate for giving an estimate of some of the environmental and population parameters of the area.

Comparisons of Yearly and Seasonal Abundance of Fishes

Comparisons of numbers of species and specimens and total weights of fishes are presented in Table 6. These are discussed in this section. In the section on the Analysis of Abundance of Fishes, the statistics of the data given in Table 6 are examined.

Table 1.—List of collections made in the surf during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971). F = Fish; I = Swimming invertebrates. Plus indicates imcomplete data; dash indicates no data taken; < indicates weights of 0.5 g or less.

Date	Temperature (°C)	Salinity (°‰)	No. of species F	No. of species I	No. of specimens F	No. of specimens I	Total weight (g) F	Total weight (g) I
1969								
11 Oct.	24.5	33.0	5	3	25	20	56	354
18 Oct.	21.0	32.8	6	1	77	4	180	135
1 Nov.	17.5	31.2	2	1	3	2	11	39
16 Nov.	11.4	32.9	5	0	54	0	312	0
2 Dec.	11.0	31.4	2	0	3	0	75	0
17 Dec.	9.3	29.0	6	0	195	0	461	0
1970								
2 Jan.	8.8	32.8	4	0	97	0	307	0
15 Jan.	6.7	27.7	7	2	39	6	1,252	39
1 Feb.	7.4	32.2	2	0	47	0	121	0
14 Feb.	8.9	32.1	2	1	58	2	162	<
1 Mar.	9.9	33.2	1	0	15	0	50	0
15 Mar.	11.1	32.6	1	0	9	0	32	0
31 Mar.	15.3	26.4	2	1	130	1	520	5
12 Apr.	16.0	23.2	2	0	14	0	63	0
25 Apr.	21.5	31.8	7	2	37	3	162	14
11 May	22.5	32.6	3	2	7	6	16	103
26 May	23.2	32.6	4	2	12	4	24	—
9 June	23.8	28.0	7	4	21	19	1,294	276
23 June	27.2	31.2	6	1	51	44	188	166+
11 July	26.7	31.2	9	4	45	8	96	16+
25 July	28.3	35.0	7	2	16	6	289	207+
8 Aug.	26.0	32.3	3	1	25	79	166	56+
24 Aug.	28.6	33.9	6	2	21	13	102	7
9 Sept.	25.6	30.2	5	2	15	8	58	108
23 Sept.	26.9	29.6	5	1	113	2	2,045	2+
10 Oct.	23.0	31.2	3	1	7	3	8	31+
24 Oct.	20.4	31.2	5	1	46	8	486	16
7 Nov.	15.3	32.3	9	0	71	0	193	0
22 Nov.	14.6	29.1	2	1	4	1	19	<
6 Dec.	13.0	29.6	4	0	74	0	229	0
22 Dec.	13.3	34.5	2	0	2	0	7	0
1971								
4 Jan.	10.2	28.0	1	0	8	0	26	0
21 Jan.	6.4	31.2	6	1	310	1	571	<
6 Feb.	9.0	27.0	5	0	244	0	626	0
20 Feb.	10.8	26.4	3	0	132	0	472	0
8 Mar.	10.9	30.2	5	1	39	1	63	—
21 Mar.	11.0	31.8	4	2	78	6	156	13
6 Apr.	14.2	30.2	5	2	13	10	186	22
17 Apr.	15.3	31.2	5	2	34	4	184	80
2 May	19.0	28.0	5	4	14	10	212	95
16 May	21.1	28.0	3	2	3	11	29	152
30 May	21.6	29.1	6	1	15	1	21	19
14 June	24.9	33.4	7	1	81	9	293	165
28 June	27.2	32.8	4	3	28	8	85	204
16 July	27.4	33.4	7	6	80	47	128	446
30 July	27.8	31.5	6	2	66	13	126	19
13 Aug.	26.8	29.6	9	1	38	1	206	1
28 Aug.	27.0	32.3	4	1	41	34	112	341
12 Sept.	26.2	32.8	8	5	161	61	319+	655
26 Sept.	24.2	29.2	3	1	12	5	14	67
10 Oct.	23.5	27.5	5	2	17	30	53+	438

Surf.—More species and more specimens of fishes were caught in the surf during the second year than in the first year, but the weight of fishes caught in the second year was only 60% of those caught in the first year (see Table 6). A considerable portion of this difference was due to the capture during the first year of 20 *Mugil cephalus* with a total weight in excess of 1.5 kg and a single specimen of *Pogonias cromis* which weighed more than 1.2 kg.

Comparisons of seasonal catches between the two years show close similarities in numbers of species in corresponding seasons except summer. The summer of the second year produced almost half again as many species as that of the first year. Winter, spring, and summer in

Table 2.—List of collections made in the tidal pool (when present) during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971). F = Fish; I = Swimming invertebrates. Plus indicates incomplete data; dash indicates no data taken; < indicates weights of 0.5 g or less.

Date	Temperature (°C)	Salinity (‰)	No. of species		No. of specimens		Total weight (g)	
			F	I	F	I	F	I
1969								
11 Oct.	26.8	—	6	1	130	2	365+	<
18 Oct.	17.0	—	5	0	14	0	38	0
16 Nov.	11.2	32.0	1	0	14	0	41	0
2 Dec.	10.8	32.0	3	1	58	12	809	—
17 Dec.	7.9	28.1	1	0	1	0	5	0
1970								
2 Jan.	8.0	32.5	1	0	5	0	22	0
15 Jan.	6.2	26.2	1	0	4	0	16	0
1 Feb.	7.3	30.7	0	0	0	0	0	0
15 Mar.	8.4	32.4	1	0	5	0	21	0
11 May	21.6	31.6	3	0	76	0	268	0
26 May	21.1	31.8	6	0	251	0	817	0
9 June	22.8	28.0	7	0	759	0	295	0
23 June	24.8	28.0	3	1	366	1	236	7
11 July	23.4	28.5	4	1	73	1	215	<
25 July	26.3	32.3	2	1	5	1	9	1
8 Aug.	24.6	30.7	4	1	159	1	239	<
9 Sept.	24.2	29.6	2	0	3	0	5	0
23 Sept.	25.6	28.5	1	0	5	0	1	0
10 Oct.	24.3	31.2	3	0	51	0	1	0
7 Nov.	14.6	31.2	5	0	52	0	149	0
22 Nov.	14.2	31.2	2	0	132	0	461	0
6 Dec.	10.7	29.6	0	0	0	0	0	0
22 Dec.	14.0	32.3	1	0	50	0	218	0
1971								
4 Jan.	11.2	25.8	3	0	17	0	67	0
21 Jan.	3.7	28.5	0	0	0	0	0	0
6 Feb.	11.0	27.0	1	0	1	0	<	0
17 Apr.	14.9	30.2	3	0	49	0	14	0
2 May	18.0	25.8	1	0	4	0	14	0
16 May	19.8	28.0	1	0	4	0	13	0
30 May	18.5	29.1	0	0	0	0	0	0
14 June	24.0	33.4	0	0	0	0	0	0
28 June	25.1	31.2	0	0	0	0	0	0
16 July	24.5	31.2	0	0	0	0	0	0
13 Aug.	24.2	29.6	0	0	0	0	0	0
12 Sept.	25.5	32.3	4	1	46	1	73	—
10 Oct.	23.0	28.0	4	1	14	2	28	1

the second year each yielded more specimens than in the first year, with winter and summer each being a great deal more productive. In each season of the first year a greater total mass of fishes was collected than in the same season in the second year.

A comparison of data for seasons for both years combined shows that more species were caught in summer than in any other season and that diversity was least in winter. In contrast, most specimens and greatest mass were obtained in winter, whereas the least number of individuals and smallest mass appeared in the spring and fall catches, respectively. For the most part, the individual years followed the same pattern. The high diversity in the warmer months was expected, but the large number of individuals and great mass caught during the winter was not anticipated. The large winter catch, relative to other seasons, may be due to at least two factors—motility and preferences for particular temperature regimes. Most of the larger, faster fishes that were caught in cold water could have easily avoided the seine when the water was warm. *Menidia menidia*, the most abundant species, was caught over a wide range of temperature (6.4°-28.3°C), but was most plentiful at the lower end of that range, whereas *Trachinotus carolinus* and *Mugil curema* (two of the most common species of fishes) were not collected at temperatures less than 14.6° and 14.9°C, respectively.

Tidal pool.—More species, more individuals, and greater mass of fishes were collected in the tidal pool during the first year than in the second year (see Table 6). These differences appear to be largely due to chance. A tidal pool was present on 18 of the collecting days each year, but only 1 of the 18 yielded no fishes or invertebrates in the first year; in contrast 7 produced no specimens in the second year. The absence of fishes from a particular collection in the tidal pool was apparently not entirely related to temperature because three collections which produced none were made in December, January, and February (water temperature: 3.7-10.7°C)

Table 3.—Summary data for *Arenaeus cribrarius* and fishes collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	Number collected and times (in parentheses)			Size range (mm SL)	Total weight (g)	Temperature range (°C)	Salinity range (°/₀₀)
	surf	tidal pool	total				
Portunidae (Decapoda, Crustacea)							
Arenaeus cribrarius	417(32)	5(3)	422(35)	[1]7-141	3,218+	11.0-28.6	27.5-35.0
Elopidae							
Elops saurus	1(1)	0	1(1)	220	111	26.2	32.8
Clupeidae							
Alosa aestivalis	22(5)	0	22(5)	42-62	29	6.4-10.9	27.7-32.8
Brevoortia smithi	1(1)	0	1(1)	89	13	6.7	27.7
Brevoortia tyrannus	18(3)	0	18(3)	49-99	87	6.4-9.3	27.0-31.2
Dorosoma petenense	1(1)	0	1(1)	73	7	28.6	33.9
Opisthonema oglinum	15(1)	0	15(1)	63-80	78	26.8	29.6
Engraulidae							
Anchoa hepsetus	22(7)	3(1)	25(8)	36-78	70	15.3-28.6	29.6-33.9
Anchoa mitchilli	362(29)	10(1)	372(30)	20-60	365	6.4-28.6	27.5-35.0
Ariidae							
Arius felis	1(1)	1(1)	2(2)	229-237	347	19.0-23.4	28.0-28.5
Cyprinodontidae							
Cyprinodon variegatus	2(1)	2(2)	4(3)	26-32	4	9.3-11.2	25.8-32.0
Fundulus heteroclitus	1(1)	3(1)	4(2)	25-38	3	11.4-14.6	31.2-32.9
Fundulus majalis	3(3)	341(15)	344(18)	26-84	744	6.2-26.8	25.8-33.0
Fundulus sp.	0	2(2)	2(2)	57	8	6.2-22.8	26.2-28.0
Atherinidae							
Membras martinica	14(8)	0	14(8)	44-83	42	9.0-26.8	23.2-33.4
Menidia beryllina	22(10)	4(4)	26(14)	46-75	53	6.4-22.8	26.4-32.9
Menidia menidia	1,485(36)	630(18)	2,115(54)	21-89	6,226	6.4-28.3	23.2-35.0
Pomatomidae							
Pomatomus saltatrix	2(2)	0	2(2)	93-122	38	23.8-26.7	28.0-31.2
Carangidae							
Caranx hippos	2(2)	0	2(2)	28-34	2	26.8-28.3	29.6-35.0
Chloroscombrus chrysurus	6(3)	0	6(3)	20-54	6	26.2-27.8	29.6-32.8
Trachinotus carolinus	266(29)	710(13)	976(42)	12-93	1,519	14.6-28.6	27.5-35.0
Trachinotus falcatus	7(5)	41(7)	48(12)	12-59	47	15.3-26.8	28.0-33.0
Trachinotus goodei	4(3)	0	4(3)	18-91	23	21.0-26.0	31.2-32.8
Gerreidae							
Eucinostomus sp.	1(1)	2(1)	3(2)	14-28	1	24.3-24.5	31.2-33.0
Sparidae							
Archosargus probatocephalus	1(1)	0	1(1)	118	70	6.7	27.7
Sciaenidae							
Bairdiella chrysura	1(1)	0	1(1)	93	17	15.3	32.3
Larimus fasciatus	4(1)	0	4(1)	15-34	4	26.2	32.8
Leiostomus xanthurus	2(2)	0	2(2)	38-102	26	21.1-21.5	28.0-31.8
Menticirrhus littoralis	291(34)	3(2)	294(36)	19-149	843	6.7-28.6	26.4-35.0
Menticirrhus saxatilis	3(2)	1(1)	4(3)	33-50	5	22.8-27.2	28.0-33.4
Menticirrhus sp.	3(2)	1(1)	4(3)	27-38	2	14.6-26.2	31.2-33.0
Pogonias cromis	1(1)	0	1(1)	328	1,228	23.8	28.0
Stellifer lanceolatus	1(1)	0	1(1)	51	3	14.2	30.2
Mugilidae							
Mugil cephalus	26(8)	47(3)	73(11)	17-328	2,426	6.4-28.3	27.0-35.0
Mugil curema	121(9)	545(7)	666(16)	19-130	2,709	14.9-28.6	28.0-35.0
Scombridae							
Scomberomorus maculatus	1(1)	0	1(1)	106	11	27.4	33.4
Triglidae							
Prionotus sp.	2(2)	0	2(2)	24-26	1	26.2-27.4	32.8-33.4
Bothidae							
Paralichthys squamilentus	17(9)	2(1)	19(10)	34-115	82	15.3-27.4	27.5-33.4
Scophthalmus aquosus	1(1)	0	1(1)	81	14	15.3	32.3
Soleidae							
Trinectes maculatus	1(1)	0	1(1)	100	45	21.5	31.8
Balistidae							
Monacanthus hispidus	6(4)	0	6(4)	16-22	2	15.3-27.0	29.1-32.3
Tetraodontidae							
Sphoeroides maculatus	5(2)	0	5(2)	14-18	2	27.2-27.8	31.5-32.8
Sphoeroides spengleri	1(1)	0	1(1)	16	<1	23.5	27.5
Diodontidae							
Chilomycterus?	2(1)	0	2(1)	12-16	1	27.4	33.4

[1] Carapace width in millimeters.

Table 4.—Number collected per month (in parentheses) and size range (mm SL) for *Arenaeus cribrarius* and fishes collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	January	February	March	April	May	June	July	August	September	October	November	December
Portunidae (Decapoda, Crustacea)												
Arenaeus cribrarius[1]	0	0	(1)28	(13)28-98	(25)17-70	(76)21-102	(57)16-140	(126)14-141	(55)7-134	(66)17-103	(3)23-79	0
Elopidae												
Elops saurus	0	0	0	0	0	0	0	0	(1)220	0	0	0
Clupeidae												
Alosa aestivalis	(15)42-55	0	(6)44-62	0	0	0	0	0	0	0	0	(1)49
Brevoortia smithi	(1)89	0	0	0	0	0	0	0	0	0	0	0
Brevoortia tyrannus	(1)83	(1)99	0	0	0	0	0	0	0	0	0	(16)49-69
Dorosoma petenense	0	0	0	0	0	0	0	(1)73	0	0	0	0
Opisthonema oglinum	0	0	0	0	0	0	0	(15)63-80	0	0	0	0
Engraulidae												
Anchoa hepsetus	0	0	0	0	0	0	(8)36-58	(2)61-72	(9)56-69	(3)68-76	(3)72-78	0
Anchoa mitchilli	(5)42-46	0	(33)34-57	(13)39-51	(21)40-59	(45)42-57	(55)32-54	(4)39-46	(126)20-54	(54)32-60	(15)38-52	(1)29
Ariidae												
Arius felis	0	0	0	0	(1)237	0	(1)229	0	0	0	0	0
Cyprinodontidae												
Cyprinodon variegatus	(1)26	0	0	0	0	0	0	0	0	0	0	(3)30-32
Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	(4)25-38	0
Fundulus majalis	(5)46-67	(1)38	0	0	(9)63-84	(24)26-74	(58)26-48	(143)31-61	(44)34-62	(2)47-63	(6)49-65	(52)45-81
Fundulus sp.	(1)57	0	0	0	0	(1)57	0	0	0	0	0	0
Atherinidae												
Membras martinica	0	(1)58	(1)44	(2)77-83	0	(2)78-80	(1)69	(2)52-54	(2)56-61	0	0	(3)48-71
Menidia beryllina	(9)52-70	(4)60-75	(3)53-62	(1)73	(2)46-63	(1)65	0	0	0	0	(2)52-61	(4)53-62
Menidia menidia	(423)49-85	(470)51-87	(226)55-89	(58)58-82	(277)57-86	(20)21-84	(4)67-87	(1)31	(1)57	(92)51-73	(248)54-82	(295)47-83
Pomatomidae												
Pomatomus saltatrix	0	0	0	0	0	(1)93	(1)122	0	0	0	0	0
Carangidae												
Caranx hippos	0	0	0	0	0	0	(1)34	(1)28	0	0	0	0
Chloroscombrus chrysurus	0	0	0	0	0	0	(1)20	(4)21-54	(1)34	0	0	0
Trachinotus carolinus	0	0	0	(1)13	(26)14-47	(695)12-75	(59)22-90	(45)19-93	(13)14-61	(121)13-77	(16)34-69	0
Trachinotus falcatus	0	0	0	0	0	(3)14-25	0	(1)52	(5)15-35	(38)12-59	(1)58	0
Trachinotus goodei	0	0	0	0	0	0	0	(1)91	0	(3)18-30	0	0
Gerreidae												
Eucinostomus sp.	0	0	0	0	0	0	0	0	0	(3)14-28	0	0
Sparidae												
Archosargus probatocephalus	(1)118	0	0	0	0	0	0	0	0	0	0	0
Sciaenidae												
Bairdiella chrysura	0	0	0	0	0	0	0	0	0	0	(1)93	0
Larimus fasciatus	0	0	0	0	0	0	0	0	(4)15-34	0	0	0
Leiostomus xanthurus	0	0	0	(1)38	(1)102	0	0	0	0	0	0	0
Menticirrhus littoralis	(1)60	(4)83-145	(5)60-75	(18)46-112	(1)82	(12)26-103	(57)19-149	(54)25-104	(71)22-94	(37)22-76	(29)28-103	(5)62-102
Menticirrhus saxatilis.	0	0	0	0	0	(4)33-50	0	0	0	0	0	0
Menticirrhus sp.	0	0	0	0	0	0	0	0	(2)33-38	(1)27	(1)36	0
Pogonias cromis	0	0	0	0	0	(1)328	0	0	0	0	0	0
Stellifer lanceolatus	0	0	0	(1)51	0	0	0	0	0	0	0	0
Mugilidae												
Mugil cephalus	(17)102-229	(1)24	(2)25-26	(47)17-211	0	0	(2)175-198	0	0	0	(1)195	(3)130-328
Mugil curema	0	0	0	(2)20-21	(36)20-25	(492)19-30	(26)21-69	(9)85-100	(75)86-130	(26)20-112	0	0
Scombridae												
Scomberomorus maculatus	0	0	0	0	0	0	(1)106	0	0	0	0	0
Triglidae												
Prionotus sp.	0	0	0	0	0	0	(1)26	0	(1)24	0	0	0

Table 4.—Continued.

Species	January	February	March	April	May	June	July	August	September	October	November	December
Bothidae												
Paralichthys squamilentus	0	0	0	(2)34-38	(11)42-58	(4)46-56	(1)82	0	0	(1)115	0	0
Scophthalmus aquosus	0	0	0	0	0	0	0	0	0	0	(1)81	0
Soleidae												
Trinectes maculatus	0	0	0	(1)100	0	0	0	0	0	0	0	0
Balistidae												
Monacanthus hispidus	0	0	0	0	(1)16	0	(2)16	(1)22	0	0	(2)18-19	0
Tetraodontidae												
Sphoeroides maculatus	0	0	0	0	0	(1)18	(4)14-18	0	0	0	0	0
Sphoeroides spengleri	0	0	0	0	0	0	0	0	0	(1)16	0	0
Diodontidae												
Chilomycterus ?	0	0	0	0	0	0	(2)12-16	0	0	0	0	0

[1] Measurements = carapace width in millimeters.

and five were made in May, June, July, and August (water temperature: 18.5°-25.1°C). Several of the pools from which no specimens were collected were for the most part extremely shallow (0.1 m or less in depth) or were oriented at the seaward end of a groin in a manner which made it impossible to make a good seine haul. Considerable portions of the discrepancies in numbers and weights between the two years were the result of the capture of large numbers of small *Fundulus majalis*, *Trachinotus carolinus*, and *Mugil curema* in the tidal pool during the first year.

Comparisons of seasonal catches between the two years show close similarities in numbers of species in all seasons except spring. The spring of the first year produced 3 times as many species as the spring of the second year. Fall and winter of the second year each yielded more specimens than their counterparts of the first year, but spring and summer of the second year each had very few specimens as compared to the corresponding season in the first year. In each season of the first year except winter a greater mass of fishes was collected than in the same season in the second year.

A comparison of data for seasons for both years combined demonstrates that species diversity was greatest in fall and spring and least in winter, that number of specimens collected was greatest in spring and least in winter, and that greatest mass was obtained in fall and least in winter. Because the first year dominated the combined catch for both years, it followed essentially the same pattern, but the second year differed considerably.

Surf and tidal pool combined.—When the surf and tidal pool were considered as a unit, the second year produced more species, but fewer specimens and less weight than the first year (see Table 6).

Comparisons of seasonal catches between the two years show close similarities in numbers of species in corresponding seasons except summer. The summer of the second year produced almost a third more species than that of the first year. With regard to numbers of specimens, fall and summer of the first year were very similar to the same seasons in the second year, but the winter of the second year produced about twice as many individuals as that of the first year and the spring of the first year 6.5 times as many as that of the second year. In each season of the first year a greater mass of fishes was collected than in the same season of the second year.

A comparison of data for seasons for both years combined shows that more species were caught in summer than in any other season, and that diversity was less in fall and spring and much less in winter. The greatest number of specimens were collected in spring and the least in summer. The greatest mass appeared in winter, but spring produced almost as much and summer and fall were not far behind. The individual years followed different patterns of seasonal distribution.

Comparison of surf with tidal pool.—During both years more species and a greater mass of fishes were

Table 5.—Summary data for swimming invertebrates (except *Arenaeus cribrarius*) collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	Number collected and times (in parentheses) surf	tidal pool	total	Season(s) collected fall	winter	spring	summer	Temperature range (°C)	Salinity range (‰)
Cnidaria									
Scyphozoa									
One (?) unidentified species (damaged)	2(2)	0	2(2)		X	X		10.9-19.0	28.0-30.2
Mollusca									
Cephalopoda									
Lolliguncula brevis	1(1)	0	1(1)	X				23.5	27.5
Annelida									
Polychaeta									
Nereis succinea	3(2)	1(1)	4(3)				X	25.5-27.4	32.3-33.4
Arthropoda									
Crustacea									
Isopoda									
Aegathoa oculata	1(1)	0	1(1)				X	28.6	33.9
Decapoda									
Acetes americanus carolinae	3(1)	0	3(1)				X	26.2	32.8
Callinectes ornatus	0	1(1)	1(1)				X	26.3	32.3
Callinectes sapidus	9(8)	12(1)	21(9)	X		X	X	10.8-28.3	28.0-35.0
Emerita talpoida	3(3)	2(2)	5(5)			X	X	19.0-26.7	28.0-31.2
Emerita sp., fragment	1(1)	0	1(1)			X		23.2	32.6
Ogyrides alphaerostris	1(1)	0	1(1)			X		27.2	32.8
Ovalipes ocellatus	14(8)	0	14(8)		X	X		11.0-23.8	26.4-31.8
Palaemonetes pugio	5(3)	0	5(3)		X		X	6.4-26.7	31.2-32.1
Penaeus setiferus	21(4)	0	21(4)		X		X	6.7-27.4	27.7-33.4
Portunus anceps	5(1)	0	5(1)				X	27.4	33.4
Portunus gibbesii	1(1)	0	1(1)				X	27.4	33.4
Trachypenaeus constrictus	1(1)	0	1(1)	X				24.5	33.0
Stomatopoda									
Squilla empusa	2(1)	0	2(1)		X			6.7	27.7
One unidentified species (larva)	1(1)	0	1(1)				X	26.7	31.2

collected in the surf than in the tidal pool (see Table 6). In the first year more specimens were captured in the tidal pool than in the surf, but in the second year the opposite was true. Captures of large numbers of small fishes in the tidal pool during the spring of the first year accounts for most of this variation between years.

Considering the first and second years combined, more species, greater numbers, and a greater mass were collected in the surf than in the tidal pool. In the surf as compared with the tidal pool, species diversity was

Table 6.—Numbers of species and specimens and total weights of fishes (in grams) collected in the surf, tidal pool, and surf and tidal pool combined at Folly Beach, S.C. (Oct. 1969-Oct. 1971).

		Surf Number species collected[1]	Number specimens collected	Total weight collected	Tidal pool Number species collected[1]	Number specimens collected	Total weight collected	Surf and tidal pool combined Number species collected[1]	Number specimens collected	Total weight collected
First year	fall	14	357	1,095	9	217	1,258	16	574	2,353
	winter	9	395	2,445	2	14	58	9	409	2,503
	spring	14	142	1,748	9	1,452	1,617	15	1,594	3,365
	summer	13	235	2,755	6	245	469	16	480	3,224
Total		28	1,129	8,043	14	1,928	3,402	29	3,057	11,445
Second year	fall	12	204	942	8	285	842	17	489	1,784
	winter	8	811	1,914	4	18	67	11	829	1,981
	spring	14	188	1,010	3	57	40	14	245	1,050
	summer	19	415	957	5	60	101	21	475	1,058
Total		31	1,618	4,823	11	420	1,050	35	2,038	5,873
First and second years comb.	fall	20	561	2,037	11	502	2,100	20	1,063	4,137
	winter	11	1,206	4,359	4	32	125	12	1,238	4,484
	spring	19	330	2,758	10	1,509	1,657	20	1,839	4,415
	summer	24	650	3,712	6	305	570	26	955	4,282
Total		41	2,747	12,866	16	2,348	4,452	41	5,095	17,318

[1] Total figure accounts for only one occurrence of each species.

greater in all seasons, number of specimens was larger in all seasons except spring, and mass was greater in all seasons except fall. The seasonal patterns for the individual years were quite similar to the preceding.

The surf zone and tidal pool are related, but quite different habitats. Their ecological relationship can be described as that of a severe, but seasonally relatively stable, environment (the surf zone) with a depauperate fauna which "regularly" contributes segments of its populations in a partly random fashion to a transient, unstable environment (the tidal pool) which reappears at predictable intervals unless certain conditions, whose appearances are largely unpredictable, intervene.

Analysis of Abundance of Fishes

Abundance in terms of numbers of species and specimens and total weight per collection was analyzed by season, year, and sampling location. A two-factor randomized complete-block design was used as the experimental model for each of the dependent variables of interest: number of species, number of specimens, and total weight of fishes per collection. Analysis of variance was employed for each of the three dependent variables in testing the null hypothesis that the effects of sampling location (factor 1, 2 levels; surf, tidal pool), season (factor 2, 4 levels; fall, winter, spring, summer), interaction between sampling location and season, and year (block, 2 levels; October 1969 through September 1970, October 1970 through September 1971) were nonsignificant. Throughout "nonsignificant" means $P > 0.05$; "significant," $0.01 < P < 0.05$; and "highly significant," $P < 0.01$. The number of collections (observations) made for the various treatment combinations was:

	Fall	*Winter*	*Spring*	*Summer*
Year 1:				
Surf	6	7	6	6
Tidal pool	5	4	4	5
Year 2:				
Surf	6	6	7	6
Tidal pool	5	3	6	3

It should be noted that the surf and tidal pool collections made on 10 October 1971 (the start of a third year) were not included in these analyses. Because the cell frequencies were unequal, an unweighted-means analysis was used as the computational procedure with the harmonic mean ($\tilde{n}_h = 4.97$) of the number of observations being used as the effective number of observations per cell for computation of main effects and interactions (Winer 1962).

One of the underlying assumptions of the analysis of variance is that of homogeneity of variance. Each set of data was examined for correlation between treatment means and their within-treatment variances. This examination suggested transformations producing homogeneity. An analysis of variance was then conducted.

The within-cell means and variances of the number of species per collection for the various treatment combinations were examined for correlations, but none were found. The within-cell variances for the number of species per collection ranged from 0.25 to 6.97. Bartlett's test for homogeneity of variance gave a χ^2 value of 11.04 for 15 df which was not significant. We then proceeded with the analysis of variance on the original data, X = number of species of fishes per collection.

Similar examinations were conducted for the number of specimens and total weight of fishes per collection. In both cases it was apparent that the variances were proportional to the means and were also heterogeneous. Bartlett's test was employed to test the hypothesis of equal within-cell variances for both the number of specimens and total weight of fishes per collection. The results of Bartlett's test were $\chi^2_{15\text{df}} = 93.19$ and $\chi^2_{15\text{df}} = 99.78$, respectively. Both χ^2 values were highly significant and we therefore rejected the hypothesis of homogeneity. It appeared that the heterogeneity was of the regular type for both the number of specimens and total weight of fishes per collection, i.e., the variability within the several treatments was proportional to the treatment means. For this reason the logarithmic transformation, $\log(X + 1)$, was used to make the means and variances independent and to stabilize the within-cell variances. The logarithmic transformation was made on the number of specimens of fishes per collection, and Bartlett's test was conducted to determine if this transformation homogenized the variances. The result of Bartlett's test on the within-cell variances for $X = \log$ (number of specimens of fishes per collection + 1) was $\chi^2_{15\text{df}} = 13.78$. Since this was nonsignificant and it appeared that no relationship remained between the means and variances of the transformed data, we then conducted the analysis of variance on the transformed data, $X = \log$ (number of specimens of fishes per collection + 1). The logarithmic transformation was also used for the total weight of fishes per collection. Bartlett's test resulted in $\chi^2_{15\text{df}} = 12.85$ for the within-cell variances of the transformed data. This was nonsignificant and the analysis of variance was then conducted on the transformed data, $X = \log$ (total weight of fishes per collection + 1).

The results of the analysis of variance for the number of species of fishes per collection (Table 7) indicate that the block or year effect is not significant. The nonsignificant location-by-season interaction shown in Table 7 indicates that the surf and tidal pool differences in number of species per collection are constant across season. The location-by-season means of number of species of fishes

Table 7.—Analysis of variance of X = number of species of fishes per collection. (* Significant, $P < 0.05$; ** highly significant, $P < 0.01$; ns not significant, $P > 0.05$.)

Source	SS	df	MS	*F*
Blocks (years)	4.92	1	4.92	1.248 ns
Location	124.85	1	124.85	31.669 **
Season	39.60	3	13.20	3.348 *
Location by season	17.04	3	5.68	1.441 ns
Error	299.61	76	3.94	
Total	486.02	84		

per collection averaged over both years are (number of collections in parentheses):

	Fall	*Winter*	*Spring*	*Summer*	*Overall*
Surf	4.25(12)	3.31(13)	4.92(13)	6.00(12)	4.60(50)
Tidal pool	2.70(10)	1.00(7)	2.40(10)	2.12(8)	2.14(35)
Overall	3.55(22)	2.50(20)	3.82(23)	4.45(20)	3.59(85)

The surf and tidal pool collections differ significantly with respect to number of species per collection when averaged over both years and all seasons (Table 7). The results of the analysis of variance also indicate a significant seasonal effect. Student-Newman-Keuls' test was used to determine which of the overall seasonal means were significantly different (Sokal and Rohlf 1969). The results indicate that only winter and summer differ significantly in number of species per collection; all other comparisons were nonsignificant.

Table 8.—Analysis of variance for X = log (number of specimens of fishes per collection + 1). (Highly significant, $P < 0.01$; ns not significant, $P > 0.05$.)**

Source	SS	df	MS	*F*
Blocks (years)	1.4906	1	1.4906	3.565 ns
Location	3.5807	1	3.5807	8.563 **
Season	0.6739	3	0.2246	0.537 ns
Location by season	6.4340	3	2.1447	5.129 **
Error	31.7783	76	0.4181	
Total	43.9575	84		

The results of the analysis of variance for the number of specimens per collection are presented in Table 8, indicating that neither the year effect nor the main effect of season is significant. On the other hand, both the main effect of location and the location-by-season interaction are highly significant. The back-transformed location-by-season means (means expressed in the original units of measurement) for both years combined are (number of collections in parentheses):

	Fall	*Winter*	*Spring*	*Summer*
Surf	20.66(12)	56.00(13)	18.88(13)	38.69(12)
Tidal pool	23.02(10)	2.50(7)	18.19(10)	8.84(8)

In view of the highly significant interaction of location and season, an examination of this interaction was undertaken to determine location differences within season; results of t-tests for surf versus tidal pool are: fall 0.16, $P > 0.05$; winter 4.00, $P < 0.01$; spring 0.06, $P > 0.05$; summer 2.05, $P < 0.05$. These single degree-of-freedom comparisons are not independent, but are warranted because the interaction is highly significant. They indicate that there is a highly significant difference between the average number of specimens per collection in the surf and the average number of specimens per collection in the tidal pool for those collections made in winter, a significant difference for summer, and a nonsignificant difference for both fall and spring.

Table 9.—Analysis of variance for X = log (total weight of fishes per collection + 1). (*Significant, $P < 0.05$; **highly significant, $P < 0.01$; ns not significant, $P > 0.05$.)

Source	SS	df	MS	*F*
Blocks (years)	4.4421	1	4.4421	8.288 **
Location	12.5504	1	12.5504	23.416 **
Season	1.2729	3	0.4243	0.792 ns
Location by season	5.8823	3	1.9608	3.658 *
Error	40.7355	76	0.5360	
Total	64.8832	84		

Table 9 gives the results of the analysis of variance for total weight per collection which indicate a highly significant difference between years for the total weight of fishes per collection. This is due in part to the capture during the first year of 20 *Mugil cephalus* with a total weight in excess of 1.5 kg and a single specimen of *Pogonias cromis* which weighed more than 1.2 kg. A variation in seining technique (see section on Materials and Methods) may have contributed to the capture of these large specimens because two short tows may have been more effective in collecting large individuals than a single long tow. The main effect of season is not significant. Both the main effect of location and the location-by-season interaction were found to be significant. The back-transformed location-by-season means (in grams) for both years combined are (number of collections in parentheses):

	Fall	*Winter*	*Spring*	*Summer*
Surf	75.87(12)	184.60(13)	101.24(13)	146.66(12)
Tidal pool	59.56(10)	5.84(7)	22.37(10)	11.34(8)

Single degree-of-freedom comparisons of location differences within season show that the surf does not differ significantly from the tidal pool for those collections made in the fall, but surf and tidal pool collections differ significantly for each of the other seasons with respect to the average total weight of fishes per collection (results of t-tests are: fall 0.33, $P > 0.05$; winter 4.18, $P < 0.01$; spring 2.08, $P < 0.05$; summer 3.23, $P < 0.01$).

Ranking of Species

The more common species (represented by at least 100 specimens) were *Arenaeus cribrarius*, *Anchoa mitchilli*, *Fundulus majalis*, *Menidia menidia*, *Trachinotus carolinus*, *Menticirrhus littoralis*, and *Mugil curema*. The six species of fishes accounted for 94% of the specimens of fishes collected (4,767 of 5,095) and 72% of the ichthyomass (12,406 of 17,318 g). One species, *Areneaus cribrarius*, made up 82% of the swimming invertebrate specimens (422 of 512) and 75% of the mass of swimming invertebrates (3,218 of 4,300 g). These species were ranked to determine their relative importance. Of the seven most important species, one (*F. majalis*) was not a significant part of the catch in the surf, and three (*A. cribrarius*, *A. mitchilli*, and *M. littoralis*) were of little consequence in the tidal pool.

We developed a seasonal index to allow ordering of species by seasonal occurrence. It is defined as:

$$\text{Seasonal index} = 1 + \log N \cdot \sum_{i=1}^{4} \frac{D_i\, C_i}{M_i}$$

where N = total number collected,
D_i = days collected in the i^{th} season,
C_i = months collected in the i^{th} season,
M_i = number of months in the i^{th} season.

Although arbitrary in its design, this index does contain the elements implicit in the meaning of seasonality, and the lower the seasonal index for a species the more seasonal is its occurrence.

Species were ranked by number of specimens, frequency of appearance (number of days collected), weight, and seasonality (seasonal index). For each of these categories the values were ordered and the highest value was given a rank of one, the second highest a rank of two, etc. In determining rank of importance, the individual ranks for each species were weighted equally and summed. The ordered sums were then ranked as "importance" (Table 10). In the surf and tidal pool combined, *M. menidia* was the most important species, followed by *A. cribrarius*, *T. carolinus*, *M. littoralis* and *M. curema*, *A. mitchilli*, and *F. majalis*.

Relationships Between Environmental Variables and Occurrence

A major objective of this study was to determine the relationships of the occurrence of the fauna to certain environmental variables using multiple regression techniques. The collections made in the surf were chosen for more detailed analyses. Effects of environmental variables on collections made in the tidal pool were not examined because conditions at the time of pool formation were not known.

Five of the most important species in the surf were selected to determine which environmental variables are important to their occurrence. The species chosen were *Arenaeus cribrarius*, *Anchoa mitchilli*, *Menidia menidia*, *Trachinotus carolinus*, and *Menticirrhus littoralis*. *Mugil curema* was not chosen because it was present in only 9 of the 51 surf collections. Five variables (duration of effort, water temperature, salinity, height of sea, and visibility of Secchi disc) were chosen for analysis. We used stepwise regression techniques to choose the "best" equation (Draper and Smith 1966) for each of the five selected species in the following manner:

1. Occurrence was plotted versus environmental variables and the data were linearized, where necessary;
2. Simple correlation coefficients between occurrence and the environmental variables were computed;
3. Using the multiple regression model, $Y = \beta + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_p Z_p + \epsilon$, where Y = occurrence, and Z_i is some function of one of the five selected environmental variables, $X_1, X_2, \ldots, X_5$, a stepwise regression was preformed to identify those parameters which account for the attributable variations in the model; and
4. For each final regression equation residuals were analyzed.

Variation within months, which we did not consider significant, was removed by using monthly averages for all data. Only temperature showed a marked seasonal effect. The mean number of specimens per collection was plotted for each species versus mean water temperature (by months). The pattern for *A. cribrarius* (Fig. 1) was typical of all species except *M. menidia* (Fig. 2). *Menidia menidia* was much more abundant at the lower water temperatures, while the converse was true for the other species. Figures 1 and 2 indicate the possible utility of the square of water temperature as an additional independent variable because the relationships appear to be curvilinear functions.

Table 10.—Rank of the seven most important species collected during Folly Beach survey (Oct. 1969-Oct. 1971). Ranks are in parentheses. Appearance equals number of days collected (because of this the number of days collected in surf and tidal pool combined does not equal number of days collected in surf plus number of days collected in tidal pool).

	Species	Number	Appearance	Weight (g)	Seasonal index	Sum of ranks	Importance
Surf:	*Menidia menidia*	1,485(1)	36(1)	4,025(1)	109.7(1)	4	1
	Arenaeus cribrarius	417(2)	32(3)	3,209(2)	76.6(2)	9	2
	Menticirrhus littoralis	291(4)	34(2)	831(5)	72.9(3)	14	3
	Anchoa mitchilli	362(3)	29(4.5)	350(6)	63.7(4)	17.5	4
	Trachinotus carolinus	266(5)	29(4.5)	1,018(4)	62.0(5)	18.5	5
	Mugil curema	121(6)	9(6)	2,591(3)	11.7(6)	21	6
Tidal pool:	*Menidia menidia*	630(2)	18(1)	2,201(1)	31.2(1)	5	1
	Trachinotus carolinus	710(1)	13(3)	501(3)	21.8(2)	9	2
	Fundulus majalis	341(4)	15(2)	734(2)	20.9(3)	11	3
	Mugil curema	545(3)	7(4)	118(4)	8.5(4)	15	4
Surf and tidal pool combined:	*Menidia menidia*	2,115(1)	40(1)	6,226(1)	126.9(1)	4	1
	Arenaeus cribrarius	422(4)	35(2)	3,218(2)	76.7(2)	10	2
	Trachinotus carolinus	976(2)	29(5)	1,519(4)	76.2(3)	14	3
	Menticirrhus littoralis	294(7)	34(3)	843(5)	73.0(4)	19	4.5
	Mugil curema	666(3)	14(7)	2,709(3)	29.2(6)	19	4.5
	Anchoa mitchilli	372(5)	30(4)	365(7)	66.5(5)	21	6
	Fundulus majalis	344(6)	16(6)	744(6)	23.0(7)	25	7

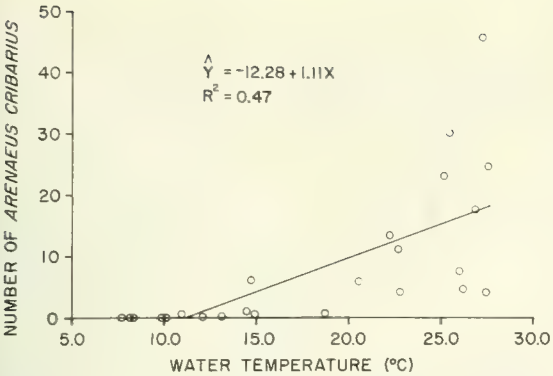

Figure 1.—Mean number of *Arenaeus cribrarius* per collection versus mean water temperature for surf collections (by months).

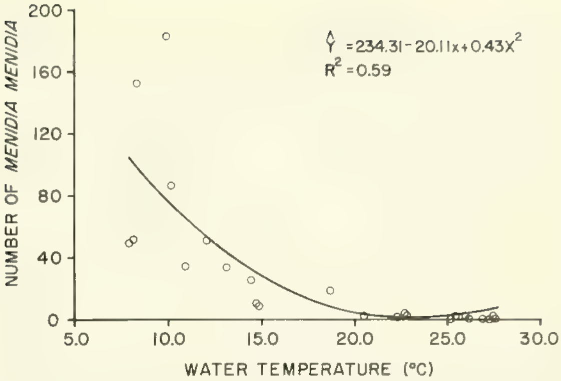

Figure 2.—Mean number of *Menidia menidia* per collection versus mean water temperature for surf collections (by months).

Table 12.—List of variables and notation for stepwise multiple regression.

Response variables Monthly average number of specimens per collection in the surf		Independent variables Monthly average in the surf	
Y_1	*Arenaeus cribrarius*	X_1	duration of effort (min)
Y_2	*Anchoa mitchilli*	X_2	water temperature (°C)
Y_3	*Menidia menidia*	X_3	salinity (°/₀₀)
Y_4	*Trachinotus carolinus*	X_4	height of sea (m)
Y_5	*Menticirrhus littoralis*	X_5	visibility of Secchi disc (m)
		X_6	square of water temperature

Simple correlation coefficients of monthly averages of environmental variables and monthly average number of specimens per collection in the surf are given in Table 11. Water temperature and its square correlated significantly with number of specimens for all species. Height of sea was significantly correlated with occurrence for *A. mitchilli* and *M. littoralis.* A significant negative correlation existed between salinity and number of specimens for *M. menidia.* No other correlations were significant.

Stepwise regression was then undertaken for each species. The list of variables and notation used is contained in Table 12. In addition to the stepwise procedure, all independent variables were forced to enter the equation (forward selection) to assess the percentage reduction of the sum of squares of deviations of Y from its mean attributed to regression.

An examination of residuals ($e_i = Y_i - \hat{Y}_i$) was conducted using the methods of Draper and Smith (1966). In conducting the regression analyses, assumptions were made about e_i: errors were independent, had zero mean and a constant variance, and followed a normal distribution. Residuals were examined to see if these assumptions were violated and to suggest possible transformations of the variables (e.g., squares and cross products of the independent variables). Residuals for the final equations selected for each species were plotted overall, in time sequence, against the fitted values $\hat{Y}_i$, and against the independent variables X_{ji}, for $j = 1, 2, \ldots, k$. Our assumptions apparently were not violated, with one exception. There appeared to be a time sequence effect for some species when the residuals were ordered by month, i.e., long runs of positive residuals followed by runs of negative residuals. A one-sample runs test was used to examine this time sequence effect. Results were not significant. It was concluded that our final equations did not violate the assumptions and no other transformations seemed relevant.

The summary statistics for the forward selection of six independent variables are given in Tables 13 through 17 along with the final equation selected by the stepwise procedure.

Water temperature (or the square of water temperature) was more highly correlated with occurrence than any of the other independent variables (Table 11). The stepwise procedure was modified to enter water temperature before its square. This modification had little effect on the results because the correlation between water temperature and its square was high ($r = 0.992$).

Table 11.—Simple correlation coefficients of monthly averages ($N = 24$) of environmental variables and monthly average number of specimens per collection in the surf for five selected species. (*Significant correlation, $P < 0.05$; **highly significant correlation, $P < 0.01$.)

Species	Duration (min)	Water temperature (°C)	Salinity (‰)	Height of sea (m)	Visibility of Secchi disc (m)	Square of water temperature (°C)²
Arenaeus cribrarius	0.080	0.683**	0.275	0.296	0.082	0.706**
Anchoa mitchilli	−0.104	0.405*	0.242	0.402*	−0.329	0.405*
Menidia menidia	−0.232	−0.711**	−0.495*	−0.167	0.056	−0.667**
Trachinotus carolinus	0.237	0.657**	0.370	0.002	0.149	0.674**
Menticirrhus littoralis	−0.219	0.497*	0.208	0.464*	−0.113	0.506*

Table 13.—Summary statistics for forward selection of six independent variables for *Arenaeus cribrarius* (Y_1 = response variable; R = correlation coefficient). (Highly significant, $P<0.01$; ns not significant, $P>0.05$.)**

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.6830	0.4665	0.4665	19.2372**
2	X_6	0.7199	0.5182	0.0517	2.2557 ns
3	X_1	0.7273	0.5290	0.0107	0.4558 ns
4	X_5	0.7301	0.5330	0.0040	0.1627 ns
5	X_3	0.7309	0.5343	0.0013	0.0494 ns
6	X_4	0.7310	0.5343	0.0000	0.0011 ns

Step 1 prediction equation: $\hat{Y}_1 = -12.2821 + 1.1120 X_2$

Table 14.—Summary statistics for forward selection of six independent variables for *Anchoa mitchilli* (Y_2 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.4046	0.1637	0.1637	4.3065*
2	X_5	0.5740	0.3295	0.1658	5.1926*
3	X_4	0.6063	0.3675	0.0380	1.2030 ns
4	X_3	0.6249	0.3905	0.0230	0.7159 ns
5	X_1	0.6558	0.4301	0.0396	1.2519 ns
6	X_6	0.6596	0.4350	0.0049	0.1471 ns

Step 2 prediction equation: $\hat{Y}_2 = 7.3141 + 0.7816 X_2 - 34.4694 X_5$

Table 15.—Summary statistics for forward selection of six independent variables for *Menidia menidia* (Y_3 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; **highly significant, $P<0.01$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.7105	0.5048	0.5048	22.4299**
2	X_6	0.7694	0.5920	0.0872	4.4892*
3	X_3	0.8409	0.7070	0.1150	7.8503*
4	X_5	0.8553	0.7316	0.0246	1.7395 ns
5	X_4	0.8619	0.7430	0.0113	0.7943 ns
6	X_1	0.8624	0.7437	0.0007	0.0494 ns

Step 3 prediction equation:

$\hat{Y}_3 = 566.8066 - 23.2452 X_2 - 10.3017 X_3 + 0.5368 X_6$

The final regression equation for *M. menidia* contained water temperature, the square of water temperature, and salinity as predictor variables. Water temperature accounted for 50% of the variation in Y due to regression ($R^2 = 0.50$). The addition of salinity and the square of water temperature as independent variables increased R^2 to 71%. Forcing the addition of the remaining variables increased R^2 to only 74%. For all other species, except *A. mitchilli*, water temperature was the only variable selected. The final regression equation selected for *A. mitchilli* contained water temperature and visibility of Secchi disc as independent variables. The best fit (R^2) was obtained for *M. menidia* ($R^2 = 0.71$), followed by *A. cribrarius* ($R^2 = 0.47$), *T. carolinus* ($R^2 = 0.43$), *A. mitchilli* ($R^2 = 0.33$), and *M. littoralis* ($R^2 = 0.25$).

Table 16.—Summary statistics for forward selection of six independent variables for *Trachinotus carolinus* (Y_4 = response variable; R = correlation coefficient). (Highly significant, $P<0.01$; ns not significant, $P>0.05$.)**

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.6569	0.4315	0.4315	16.7013**
2	X_4	0.7115	0.5063	0.0747	3.1787 ns
3	X_6	0.7348	0.5399	0.0337	1.4634 ns
4	X_3	0.7392	0.5464	0.0064	0.2698 ns
5	X_5	0.7414	0.5497	0.0034	0.1340 ns
6	X_1	0.7415	0.5498	0.0001	0.0029 ns

Step 1 prediction equation: $\hat{Y}_4 = -7.6441 + 0.7025 X_2$

Table 17.—Summary statistics for forward selection of six independent variables for *Menticirrhus littoralis* (Y_5 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.4969	0.2469	0.2469	7.2144*
2	X_1	0.5909	0.3492	0.1022	3.2991 ns
3	X_4	0.6372	0.4060	0.0568	1.9124 ns
4	X_3	0.6697	0.4485	0.0426	1.4664 ns
5	X_6	0.6835	0.4672	0.0187	0.6313 ns
6	X_5	0.6993	0.4890	0.0218	0.7249 ns

Step 1 prediction equation: $\hat{Y}_5 = -4.6371 + 0.5718 X_2$

Ordering the regression equations on the basis of R^2 for the five selected species resulted in the same ranking as the "importance" for surf and tidal pool combined (Table 10) with the exception of a reversal of order between *A. mitchilli* and *M. littoralis*.

Livingston et al. (1976) performed similar regression analyses for species collected in a study of Apalachicola Bay, Fla. The only species analyzed in both their study and ours was *Anchoa mitchilli*. Of the independent variables examined for this species by Livingston et al. only chlorophyll a and visibility of Secchi disc were significant contributors to R^2 (with chlorophyll a being more important). Their R^2 for *A. mitchilli* was 0.38. Clarity of water (by visibility of Secchi disc), then, is an important factor in determining the presence of *A. mitchilli*.

Annotated List of Selected Species

The seven species included in the section on ranking and several others are considered below in some detail. Temperature and salinity ranges for these species are presented in Table 3; and numbers and size ranges by month are given in Table 4.

Arenaeus cribrarius (Lamarck) (Crustacea, Decapoda, Portunidae). This species was collected in spring, summer, and fall of both years and in winter (one specimen in March) of the second year. In 35 collections (32 from the surf and 3 from the tidal pool), 422 specimens of 7 to 141 mm CW (417, 7-141 mm CW, from the surf and 5, 17-59 mm CW, from the tidal pool) of *A.*

cribrarius weighing 3,218 g (3,209 from the surf and 9 from the tidal pool) were captured. The relationship of mean number per collection and mean station water temperature (in the surf by months) is shown in Figure 1; and carapace width frequency data for tidal pool and surf combined, in Table 18. Ovigerous females were collected as early as mid-June and recently spawned ones as late as mid-September. These data, along with the presence of small individuals (20 mm CW or smaller) from May through October, show that *A. cribrarius* has a prolonged spawning period.

Alosa aestivalis (Mitchill) (Clupeidae). In five collections (all from the surf), 22 specimens of 42 to 62 mm SL of *Alosa* were collected. As Berry (1964) pointed out, it is difficult to identify small specimens of *Alosa* using any description or key. The characters which appear to be most useful in identifying the species of the Atlantic drainage (*A. sapidissima*, *A. mediocris*, *A. aestivalis*, and *A. pseudoharengus*) are the number of gill rakers on the lower limb of the anterior gill arch and total number of vertebrae (Hildebrand 1963; Berry 1964). Our specimens have lower-limb gill raker counts of 36 to 41 ($\bar{x}$ = 37.82) and vertebral counts of 49 to 51 ($\bar{x}$ = 50.00). The high gill raker counts eliminate *Alosa mediocris* and the low vertebral counts remove *A. sapidissima* from further consideration. According to Hildebrand (1963), *Alosa aestivalis* has 49 to 53 vertebrae, whereas *A. pseudoharengus* has 46 to 50. Both *A. aestivalis* and *A. pseudoharengus* show an increase in number of gill rakers with growth until adult sizes are reached (Hildebrand 1963). Hildebrand (1963) gave lower-limb gill raker counts as follows: *A. aestivalis*, specimens of 30 to 49 mm SL—28 to 36, specimens of 50 to 69 mm SL—30 to 39; *A. pseudoharengus*, specimens of 30 to 49 mm SL—25 to 33, specimens of 50 to 69 mm SL—32 to 36. Our material, then, is more similar to *Alosa aestivalis* (Mitchill) than to *Alosa pseudoharengus* (Wilson). We have, therefore, considered our specimens of *Alosa* as *A. aestivalis*.

Dorosoma petenense (Günther) (Clupeidae). One specimen of 73 mm SL of *Dorosoma petenense* was collected in the surf on 24 August 1970. Although *D. petenense* has been introduced into freshwater reservoirs in the southeast, we have found no record published prior to 1974 of its occurring in the estuarine or marine waters of South Carolina. According to Miller (1963), it has been collected from the Gulf Coast of the United States and southward to northern Guatemala and British Honduras. Donald C. Scott (University of Georgia) stated (pers. commun.) that in addition to its having been introduced into reservoirs in Georgia, there was a native stock of *D. petenense* present at least as far back as 1955 in the Satilla River which drains into the Atlantic, and, at present, it is widespread along the coast having been taken in beach collections at Sapelo and near Brunswick and Savannah. Miller and Jorgenson (1969) reported this species from collections made in the surf at St. Simons Island, Ga. In addition to the specimen collected at Folly Beach, one was collected on 9 February 1970 near Dewees Inlet at the northeast end of the Isle of Palms, in Charleston County (lat. 32°48.8′N, long. 79°43.0′W). Shealy et al. (1974) collected numerous specimens in 1973-74 during a survey of South Carolina's estuaries.

Anchoa mitchilli (Valenciennes) (Engraulidae). This species was collected in all seasons of both years, least commonly in winter. In 30 collections (29 from the surf and 1 from the tidal pool), 372 specimens of 20 to 60 mm SL (362, 20-60 mm SL, from the surf and 10, 47-58 mm SL, from the tidal pool) of *A. mitchilli* weighing 365 g (350 from the surf and 15 from the tidal pool) were collected.

Table 18.—Carapace width frequencies (%) by month for *Arenaeus cribrarius* collected in tidal pool and surf combined during the Folly Beach survey. One specimen of 140.8 mm CW, collected in August 1971, is denoted by an asterisk.

	Carapace width (mm)														
Month	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	*N*
1969															
Oct.		13.0		34.8	4.3	8.7	17.4	4.3	13.0		4.3				23
Nov.					50.0			50.0							2
1970															
Apr.				100.0											1
May		12.5	25.0	12.5	12.5	25.0	12.5								8
June		1.7	15.3	42.4	23.7	3.4	11.9	1.7							59
July		25.0	12.5	25.0	12.5	12.5		12.5							8
Aug.		4.4	86.8	8.8											91
Sept.		11.1	33.3	44.4			11.1								9
Oct.		27.3	27.3	18.2	9.1	9.1		9.1							11
Nov.			100.0												1
1971															
Mar.			100.0												1
Apr.			41.7	33.3	8.3		8.3			8.3					12
May			20.0	6.7	13.3		60.0								15
June			46.7	20.0			6.7			20.0	6.7				15
July		20.4	51.0	10.2	10.2	2.0			4.1					2.0	49
Aug.		60.0	20.0	5.7	2.9	2.9	2.9			2.9				2.9*	35
Sept.	4.3	6.5	50.0	23.9	2.2		2.2	2.2	2.2			2.2	2.2	2.2	46
Oct.		3.2		12.9	12.9	35.5	12.9	12.9	6.5	3.2					31
															417

Fundulus majalis (Walbaum) (Cyprinodontidae). Although this species was collected in all seasons of both years except the spring of the second year, 71% of the specimens were obtained during the summer. In 18 collections (3 from the surf and 15 from the tidal pool), 344 specimens of 26 to 84 mm SL (3, 38-67 mm SL, from the surf, and 341, 26-84 mm SL, from the tidal pool) of *F. majalis* weighing 744 g (10 from the surf and 734 from the tidal pool) were collected.

Menidia spp. (Atherinidae). Rubinoff and Shaw (1960) separated *Menidia beryllina* (Cope) collected in Massachusetts from *M. menidia* (Linnaeus) collected in Massachusetts and New York mainly on the basis of number of soft rays in the anal fin. Their 251 specimens of *M. beryllina* had a range of 14 to 19, usually 15 to 17, anal soft rays ($\bar{x}$ = 15.6), whereas their 134 specimens of *M. menidia* had a range of 20 to 29, usually 22 to 25 ($\bar{x}$ = 23.5). In Rubinoff and Shaw's collections only one specimen had 19 anal soft rays and only one had 20. They assigned these specimens to species on the basis of size and total number of lateral scales.

Robbins (1969) examined *M. beryllina* collected from Massachusetts to Vera Cruz, Mexico, and *M. menidia* from Prince Edward Island to northeastern Florida. In 1,952 specimens of *M. beryllina*, he found a range of 12 to 21, usually 15 to 18, anal soft rays ($\bar{x}$ = 16.37), and in 1,504 specimens of *M. menidia* a range of 19 to 29, usually 21 to 26 ($\bar{x}$ = 23.60).

The distribution of counts of anal soft rays for 1,658 of our 2,141 specimens of *Menidia* is:

	N	%
16	1	0.1
17	0	0.0
18	3	0.2
19	16	1.0
20	94	5.7
21	292	17.6
22	511	30.8
23	415	25.0
24	223	13.4
25	85	5.1
26	16	1.0
27	1	0.1
28	1	0.1

Because the distribution appears almost normal there may be only one species of this genus represented in our collections. A contrary interpretation, and the one that we prefer, is that both *Menidia beryllina* and *M. menidia* are present, but due to overlap in ranges of counts of anal soft rays there is no clear line of demarcation between the species using this character. On a number of specimens, representing the entire range of counts of anal fin rays recorded, we counted total vertebrae and lateral scales. These counts were of little help in separating the two species. Weighing the preceding, we arbitrarily considered specimens of *Menidia* with 19 or fewer anal soft rays as *M. beryllina* and those with 20 or more as *M. menidia*.

In 14 collections (10 from the surf and 4 from the tidal pool), 26 specimens of 46 to 75 mm SL (22, 52-75 mm SL, from the surf and 4, 46-65 mm SL, from the tidal pool) of *M. beryllina* weighing 53 g (44 from the surf and 9 from the tidal pool) were obtained. This species was collected in the autumn and winter of both years and in the spring of the first year.

In 54 collections (36 from the surf and 18 from the tidal pool), 2,115 specimens of 21 to 89 mm SL (1,485, 21-89 mm SL, from the surf and 630, 31-86 mm SL, from the tidal pool) of *M. menidia* weighing 6,226 g (4,025 from the surf and 2,201 from the tidal pool) were obtained. This species was collected in all seasons of both years. However, 53% of the specimens were seined in winter and less than 0.5% in summer. The relationship of mean number per collection and mean station water temperature (in the surf by months) is shown in Figure 2. Small individuals of *M. menidia* utilize habitats other than those of the surf zone. Only about 0.4% of the specimens collected were 50 mm SL or smaller (Table 19). We do not believe that the virtual absence of *M. menidia* less than 50 mm SL is an artifact of the collecting method because we collected numbers of small individuals of similarly shaped species. Ripe individuals were noted from late March to early June. Cupka (1972) found sexually mature specimens from mid-March through early June.

Trachinotus carolinus (Linnaeus) (Carangidae). This species was collected in both years in all seasons except winter, but 68% of the specimens were seined in the spring of the first year. Most of those caught in that season were less than 30 mm SL and from the tidal pool (Table 20). Almost 61% of the total number were obtained from the tidal pool on two successive collecting days in June 1970. A prolonged spawning period is indicated for this species because small specimens (22 mm SL or smaller) were caught from mid-April through late October (specimens 14 mm SL or smaller in April, May, June, September, and October). This is similar to the findings of several other authors (Fields 1962; Finucane 1969; Bellinger and Avault 1970; Cupka 1972). In 42 collections (29 from the surf and 13 from the tidal pool), 976 specimens of 12 to 93 mm SL (266, 12-93 mm SL, from the surf and 710, 12-66 mm SL, from the tidal pool) of *T. carolinus* weighing 1,519 g (1,018 from the surf and 501 from the tidal pool) were obtained.

Menticirrhus littoralis (Holbrook) (Sciaenidae). Although this species was collected in all seasons of both years, 62% of the specimens were obtained in summer, but only about 3% in winter. In 36 collections (34 from the surf and 2 from the tidal pool), 294 specimens of 19 to 149 mm SL (291, 19-149 mm SL, from the surf and 3, 31-76 mm SL, from the tidal pool), of *M. littoralis* weighing 843 g (831 from the surf and 12 from the tidal pool) were collected. Hildebrand and Cable (1934) suggested that spawning starts near Cape Lookout, N.C., no later than 1 May and continues into August. The capture of individuals measuring less than 30 mm SL from June through November during our survey indicates a similar situation off South Carolina with spawning probably extending into September (Table 21). Tagatz and Dudley

Table 19.—Standard length frequencies (%) by month for *Menidia menidia* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	Standard length (mm)												
	21-30		41-50		51-60		61-70		71-80		81-90		
Month	T	S	T	S	T	S	T	S	T	S	T	S	*N*
1969													
Oct.			1.1		50.0	1.1	37.5	6.8	3.4				88
Nov.					6.3	14.1	15.6	53.1		10.9			64
Dec.				1.3	3.1	38.6	14.9	31.6	5.3	3.9	0.9	0.4	228
1970													
Jan.				1.0	1.0	36.9	1.0	51.5	1.9	5.8	1.0		103
Feb.						20.8		67.3		11.9			101
Mar.						3.8	1.3	46.5	1.9	44.6		1.9	157
Apr.						2.8		36.1		61.1			36
May					3.1		42.0	0.8	51.1	0.4	2.7		262
June							43.8	12.5	31.2	6.3	6.3		16
July								50.0		25.0		25.0	4
Aug.	100.0												1
Oct.								100.0					2
Nov.					11.4	1.6	51.6	3.8	26.6	3.3	1.6		184
Dec.						35.3		55.9		7.4		1.5	67
1971													
Jan.				0.3		49.1	1.9	40.9	2.5	5.0	0.3		320
Feb.						10.6		57.5		30.5		1.4	367
Mar.						23.2		60.9		15.9			69
Apr.						4.5	4.5	36.4	9.1	40.9		4.5	22
May							20.0	26.7	33.3	20.0			15
June		25.0						25.0		50.0			4
Sept.					100.0								1
Oct.					50.0		50.0						2
													2,113

(1961) also reported specimens of similar size taken from June through November near Cape Lookout, N.C.

Mugil cephalus Linnaeus (Mugilidae). Although this species was collected in fall (1969), winter (1970 and 1971), spring (1971), and summer (1970), most specimens were collected in winter (27%) and spring (64%). In 11 collections (8 from the surf and 3 from the tidal pool), 73 specimens of 17 to 328 mm SL (26, 25-229 mm SL from the surf and 47, 17-328 mm SL from the tidal pool) of *M. cephalus* weighing 2,426 g (1,786 from the surf and 640 from the tidal pool) were obtained. Even though *Mugil cephalus* outranks four of the seven most impor-

Table 20.—Standard length frequencies (%) by month for *Trachinotus carolinus* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	Standard length (mm)															
	11-20		21-30		31-40		41-50		51-60		61-70		71-80	81-90	91-100	
Month	T	S	T	S	T	S	T	S	T	S	T	S	S	S	S	*N*
1969																
Oct.		1.3	30.7	8.0	17.3	5.3	6.7	6.7	9.3	5.3	5.3	2.7	1.3			75
Nov.						50.0				50.0						2
1970																
May	5.6	5.6	55.5	22.1		5.6		5.6								18
June	37.3	0.3	36.5	1.7	13.0	1.2	3.1	2.0	1.7	0.9		2.0	0.2			646
July			3.0	21.2		21.2	3.0	36.4	3.0	9.1				3.0		33
Aug.		5.9	29.4	5.9	11.8			8.8		14.7		8.8	11.8	2.9		34
Sept.	37.5	12.5	25.0			12.5				12.5						8
Oct.	25.0	5.6	33.3	11.1		13.9		5.6		2.8		2.8				36
Nov.					7.1		28.6	7.1		42.9		14.3				14
1971																
Apr.		100.0														1
May		12.5		62.5		25.0										8
June		4.1		2.0		8.2		18.4		38.8		22.4	6.1			49
July				26.9		23.1		38.5		11.5						26
Aug.				27.3				27.3		9.1		18.2	9.1		9.1	11
Sept.	20.0	20.0	20.0							20.0		20.0				5
Oct.			44.4	11.1			11.1			22.2		11.1				9
																975

Table 21.—Standard length frequencies (%) by month for *Menticirrhus littoralis* collected in the surf during the Folly Beach survey.

Month	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	141-150	*N*
1969													
Oct.		16.7	27.8	22.2	16.7	5.6	11.1						18
Nov.				50.0	50.0								2
1970													
Jan.					100.0								1
Apr.								100.0					1
June		12.5	50.0		25.0		12.5						8
July	50.0			50.0									2
Aug.			21.1	21.1	36.8	10.5	10.5						19
Sept.		25.0	8.3	33.3	8.3		8.3		16.7				12
Oct.			11.1	33.3	33.3	22.2							9
Nov.		37.0	33.3	18.5	7.4					3.7			27
Dec.						60.0	20.0			20.0			5
1971													
Feb.								25.0	25.0	25.0		25.0	4
Mar.					20.0	60.0	20.0						5
Apr.				23.5	11.8	23.5	5.9	17.6	11.8		5.9		17
May								100.0					1
June			25.0	50.0						25.0			4
July	3.6	23.6	30.9	18.2	5.5	10.9	3.6	1.8				1.8	55
Aug.		17.1	22.9	42.9	11.4	2.9				2.9			35
Sept.		11.9	23.7	30.5	20.3	8.5	5.1						59
Oct.		14.3	71.4	14.3									7
													291

Standard length (mm)

tant species in weight (Table 10), it was not considered with that group because it was represented by a relatively small number of specimens.

Mugil curema Valenciennes (Mugilidae). This species was collected in both years in all seasons except winter. Seventy-nine percent of the specimens (all less than 30 mm SL) were caught in the first spring, whereas 15% (most between 86 and 130 mm SL) were caught during the first summer (Table 22). In 16 collections (9 from the surf and 7 from the tidal pool), 666 specimens of 19 to 130 mm SL (121, 22-130 mm SL, from the surf and 545, 19-73 mm SL, from the tidal pool) of *M. curema* weighing 2,709 g (2,591 from the surf and 118 from the tidal pool) were obtained.

Paralichthys squamilentus Jordan and Gilbert (Bothidae). This species was collected in spring of both years (89% of total), summer of the second year, and in October 1971. In 10 collections (9 from the surf and 1 from the tidal pool), 19 specimens of 34 to 115 mm SL (17, 34-115 mm SL, from the surf and 2, 44-58 mm SL, from the tidal pool) of *P. squamilentus* weighing 82 g (76 from the surf and 6 from the tidal pool) were collected. Bearden (1971) noted that few records of juvenile *Paralichthys squamilentus* have appeared in the

Table 22.—Standard length frequencies (%) by month for *Mugil curema* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	11-20	21-30		61-70	71-80		81-90	91-100	101-110	111-120	121-130	
Month	T	T	S	S	T	S	S	S	S	S	S	*N*
1969												
Oct.	100.0											1
1970												
May	23.5	76.5										34
June	0.8	99.2										492
July	5.0	75.0	10.0	10.0								20
Aug.								100.0				3
Sept.							2.7	36.0	41.3	18.7	1.3	75
Oct.						8.3	25.0	45.8	12.5	8.3		24
1971												
Apr.	100.0											2
May		100.0										2
July			100.0									6
Aug.							66.7	33.3				6
Oct.					100.0							1
												666

Standard length (mm)

literature. He reported 60 juvenile specimens (25-88 mm SL) of *P. squamilentus* caught in shallow water (0.3-1.3 m) at nine open ocean beach stations in South Carolina in May and June 1969. Cupka (1972) collected two specimens (56-97 mm SL, one in May 1971 and one in August 1971) from the surf zone in South Carolina. Bearden (1971) offered two possible explanations for the appearance of *P. squamilentus* off the beaches of South Carolina in 1969: 1) 1969 may have been a year when spawning was unusually successful, or 2) the juveniles of *P. squamilentus* may have been misidentified or overlooked previously. Because we collected juveniles of *P. squamilentus* in the two succeeding years, the appearance of juveniles of this species in 1969 does not seem unusual. A more plausible interpretation of the data is that the apparent absence of juveniles of *P. squamilentus* in the waters of South Carolina before 1969 is the result for the most part of inadequate collecting.

Sphoeroides spengleri (Bloch) (Tetraodontidae). One specimen, 16 mm SL, of *S. spengleri* was collected from the surf on 10 October 1971. Shipp and Yerger (1969) stated that *S. spengleri* is "Widespread in the western Atlantic and adjacent waters, in shallow water." Our specimen was identified by Robert L. Shipp (University of South Alabama) who wrote one of us (24 March 1972) that *S. spengleri* wanders as far north as Massachusetts and is fairly common at Bermuda, but to his knowledge this is the first record from South Carolina.

Chilomycterus ? (Diodontidae). Two specimens, 12 to 16 mm SL, of a diodontid were collected from the surf on 16 July 1971 after the passage of a tropical storm. These fish resemble *Lyosphaera globosa* as shown in pl. 267 of Jordan and Evermann (1900). According to Fraser-Brunner (1943), *Lyosphaera* is a junior synonym of *Chilomycterus*.

Relationships of Lengths and Lengths to Weight

The relationships of carapace length to carapace width and these measurements to weight are presented in Table 23 for the decapod crustacean *Arenaeus cribrarius*. The relationships of lengths and lengths to weight are presented in Tables 24 through 31 for the following fishes: *Anchoa mitchilli, Fundulus majalis, Menidia menidia, Trachinotus carolinus, Trachinotus falcatus, Menticirrhus littoralis, Mugil cephalus*, and *Mugil curema*. All lengths of fishes were measured from the tip of the snout: standard length, to the structural base of the caudal fin; fork length, to the bifurcation of the caudal fin; and total length, to the distal tip of the longest caudal ray.

Equations of length to length relationships were derived by the method of least squares and are of the form $Y = a + bX$ (where Y = dependent variable or predicted length, a = Y intercept, b = coefficient of regression, and X = independent variable or observed length). Equations of length to weight were also obtained by the method of least squares after a $\log_{10}$ -$\log_{10}$ transformation of the original data, and are of the form $Y = a + bX$ (where Y = log weight and X = log length). This transformation was used to convert the analyses from curvilinear to simple linear regression. For each regression analysis we have included the sum of squares and cross products of deviations for ease of comparison with other data. In Tables 23 through 31 the following notations are used: N = sample size, X = independent variable, Y = dependent variable, a = Y intercept, b = coefficient of regression, r = product-moment correlation coefficient, Σx^2 = sum of squares of deviations of X, Σy^2 = sum of squares of deviations of Y, and Σxy = sum of cross products of deviations of X and Y.

RECOMMENDATIONS

Several ways in which a collecting program such as ours might be improved and provide better sampling and understanding of the area studied are:

1. Collect additional physical data, such as current velocity;
2. Make replicate tows through the collecting site (preserving the material from each tow separately);
3. Establish replicate collecting sites nearby;
4. Use a larger seine for longer tows in deeper water to supplement the collecting;
5. Collect at several stages of the tide, at midday and at night, and during various phases of the moon;
6. Sample for a longer period of time;
7. Make a special effort to gather additional biological data, such as information on spawning, fecundity, food habits, incidence of ectoparasitism; and
8. Use field and laboratory data sheets from which data can be key punched directly without transcription.

A program incorporating the methods used in this study and the above recommendations should provide

Table 23.—Carapace length-carapace width, carapace length-weight, and carapace width-weight regression statistics for N = 352 specimens of *Arenaeus cribrarius*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
CW	CL	−1.1686	0.4659	0.996	160,001.63990	34,989.03111	74,550.70835
CL	CW	2.7690	2.1307	0.996	34,989.03111	160,001.63990	74,550.70835
log CW	log W	−4.7894	3.3004	0.977	15.95073	181.96342	52.64344
log CL	log W	−3.4380	3.1801	0.983	17.38521	181.96342	55.28680

	CW (mm)	CL (mm)	W (g)
Mean	38.59	16.81	7.99
Range	7.0-140.8	4.0-65.6	0.07-222.9

Table 24.—Length-length and length-weight regression statistics for N = 215 specimens of *Anchoa mitchilli*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	3.7405	1.0208	0.980	7,021.48493	7,610.26633	7,167.23298
SL	TL	2.3699	1.1657	0.963	7,021.48493	10,290.75656	8,185.22423
FL	SL	−1.7622	0.9418	0.980	7,610.26633	7,021.48493	7,167.23298
FL	TL	−1.0110	1.1243	0.967	7,610.26633	10,290.75656	8,556.17275
TL	SL	1.4286	0.7954	0.963	10,290.75656	7,021.48493	8,185.22423
TL	FL	4.1155	0.8314	0.967	10,290.75656	7,610.26633	8,556.17275
log SL	log W	−6.0330	3.6360	0.951	0.66723	9.75842	2.42602
log FL	log W	−6.4963	3.8170	0.951	0.60589	9.75842	2.31271
log TL	log W	−6.2989	3.6100	0.941	0.66381	9.75842	2.39633

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	45.53	50.22	55.45	1.08
Range	27.5-59.9	30.9-64.4	33.4-77.0	0.20-2.78

Table 25.—Length-length and length-weight regression statistics for N = 341 specimens of *Fundulus majalis*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	TL	1.7211	1.1722	0.999	39,435.90452	54,339.91062	46,226.10678
TL	SL	−1.3361	0.8507	0.999	54,339.91062	39,435.90452	46,226.10678
log SL	log W	−5.1305	3.2532	0.995	3.31912	35.50605	10.79770
log TL	log W	−5.5353	3.3303	0.995	3.16801	35.50605	10.55051

	SL (mm)	TL (mm)	W (g)
Mean	45.05	54.52	2.19
Range	26.0-84.1	31.8-98.5	0.25-12.25

Table 26.—Length-length and length-weight regression statistics for N = 500 specimens of *Menidia menidia*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	3.4715	1.0872	0.997	27,732.99210	33,001.74800	30,151.30480
SL	TL	5.7405	1.1396	0.991	27,732.99210	36,673.69960	31,604.49710
FL	SL	−2.7378	0.9136	0.997	33,001.74800	27,732.99210	30,151.30480
FL	TL	2.2339	1.0464	0.993	33,001.74800	36,673.69960	34,533.23480
TL	SL	−3.7872	0.8618	0.991	36,673.69960	27,732.99210	31,604.49710
TL	FL	−1.0206	0.9416	0.993	36,673.69960	33,001.74800	34,533.23480
log SL	log W	−5.0377	3.0341	0.929	1.25294	13.36788	3.80155
log FL	log W	−5.4685	3.1716	0.934	1.15954	13.36788	3.67758
log TL	log W	−5.7295	3.2553	0.943	1.12077	13.36788	3.64845

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	64.72	73.83	79.49	3.00
Range	30.8-88.9	35.4-96.7	38.0-107.0	0.24-7.48

Table 27.—Length-length and length-weight regression statistics for N = 500 specimens of *Trachinotus carolinus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.2582	1.1215	0.999	116,132.82810	146,309.33380	130,241.53720
SL	TL	−0.6558	1.3240	0.998	116,132.82810	204,204.72070	153,753.67220
FL	SL	−1.0732	0.8902	0.999	146,309.33380	116,132.82810	130,241.53720
FL	TL	−2.1288	1.1802	0.999	146,309.33380	204,204.72070	172,666.97750
TL	SL	0.5817	0.7529	0.998	204,204.72070	116,132.82810	153,753.67220
TL	FL	1.8689	0.8456	0.999	204,204.72070	146,309.33380	172,666.97750
log SL	log W	−4.9662	3.2714	0.996	20.71864	223.58965	67.77955
log FL	log W	−5.3659	3.3869	0.996	19.34027	223.58965	65.50392
log TL	log W	−5.2538	3.2184	0.996	21.41597	223.58965	68.92533

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	27.94	32.59	36.33	1.42
Range	11.8-93.0	14.1-104.1	15.7-123.9	0.03-24.88

Table 28.—Length-length and length-weight regression statistics for $N = 45$ specimens of *Trachinotus falcatus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.6501	1.0962	0.9997	5,485.89911	6,596.88311	6,013.79711
SL	TL	0.1357	1.2980	0.9988	5,485.89911	9,264.20800	7,120.66133
FL	SL	−1.4883	0.9116	0.9997	6,596.88311	5,485.89911	6,013.79711
FL	TL	−1.8078	1.1837	0.9989	6,596.88311	9,264.20800	7,808.62933
TL	SL	−0.0483	0.7686	0.9988	9,264.20800	5,485.89911	7,120.66133
TL	FL	1.5879	0.8429	0.9989	9,264.20800	6,596.88311	7,808.62933
log SL	log W	−4.0249	2.7452	0.9429	1.17563	9.96602	3.22731
log FL	log W	−4.4235	2.8910	0.9393	1.05202	9.96602	3.04141
log TL	log W	−4.3651	2.7614	0.9468	1.17158	9.96602	3.23522

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	24.00	27.96	31.29	1.03
Range	12.1-59.4	14.3-66.8	16.2-75.9	0.09-8.66

Table 29.—Length-length and length-weight regression statistics for $N = 291$ specimens of *Menticirrhus littoralis*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	TL	1.2032	1.2172	0.998	114,966.97810	171,061.35680	139,935.44470
TL	SL	−0.7740	0.8180	0.998	171,061.35680	114,966.97810	139,935.44470
log SL	log W	−4.7160	2.9514	0.992	7.60448	67.38193	22.44407
log TL	log W	−5.0851	3.0019	0.991	7.34690	67.38193	22.05480

	SL (mm)	TL (mm)	W (g)
Mean	48.96	60.79	2.88
Range	19.2-149.1	24.4-181.2	0.10-45.90

Table 30.—Length-length and length-weight regression statistics for $N = 48$ specimens of *Mugil cephalus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.6494	1.1462	0.9997	287,624.41670	378,110.61480	329,671.25420
SL	TL	−0.2732	1.2703	0.9997	287,624.41670	464,347.77310	365,360.01750
FL	SL	−1.3811	0.8719	0.9997	378,110.61480	287,624.41670	329,671.25420
FL	TL	−2.0735	1.1080	0.9998	378,110.61480	464,347.77310	418,941.18560
TL	SL	0.2608	0.7868	0.9997	464,347.77310	287,624.41670	365,360.01750
TL	FL	1.9075	0.9022	0.9998	464,347.77310	378,110.61480	418,941.18560
log SL	log W	−5.1821	3.2163	0.9995	9.39197	97.25856	30.20757
log FL	log W	−5.5090	3.2681	0.9995	9.09758	97.25856	29.73201
log TL	log W	−5.4259	3.1764	0.9996	9.63288	97.25856	30.59741

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	87.69	102.16	111.12	49.31
Range	18.2-328.0	21.8-370.0	22.3-413.0	0.07-586.0

Table 31.—Length-length and length-weight regression statistics for $N = 394$ specimens of *Mugil curema*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	0.5761	1.1722	0.9985	470,299.87390	648,206.35520	551,308.74100
SL	TL	−0.7066	1.2848	0.9997	470,299.87390	776,685.93360	604,216.83340
FL	SL	−0.3563	0.8505	0.9985	648,206.35520	470,299.87390	551,308.74100
FL	TL	−1.1853	1.0931	0.9986	648,206.35520	776,685.93360	708,547.91860
TL	SL	0.5739	0.7780	0.9997	776,685.93360	470,299.87390	604,216.83340
TL	FL	1.2302	0.9123	0.9986	776,685.93360	648,206.35520	708,547.91860
log SL	log W	−5.1563	3.2558	0.9984	30.99242	329.57610	100.90500
log FL	log W	−5.4521	3.2860	0.9979	30.39528	329.57610	99.87731
log TL	log W	−5.4166	3.2148	0.9986	31.79767	329.57610	102.22395

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	44.79	53.08	56.83	6.66
Range	19.1-130.4	23.0-155.5	24.1-168.0	0.10-49.60

adequate data for developing basic models of either the shallow-water estuarine or surf-zone ichthyofauna occurring over shell-hash, sandy, or muddy bottoms and should be useful both in identifying natural perturbations and artificial stresses and in predicting their effects.

CONCLUSIONS AND SUMMARY

1. Fifty-one collections were made in the surf and 36 in the tidal pool from which some 512 specimens of swimming invertebrates representing at least 17 species and 5,095 specimens of bony fishes representing 41 species were collected.

2. The surf and tidal pool collections differ significantly with respect to number of species per collection when averaged over both years and all seasons.

3. Winter and summer differ significantly in number of species per collection.

4. Both the main effect of location and the location-by-season interaction show highly significant differences in number of specimens per collection.

5. There is a highly significant difference between the average number of specimens per collection in the surf versus the tidal pool for those collections made in winter and a significant difference for summer.

6. There is a highly significant difference between years for the total weight of fishes per collection. This is due in part to the capture during the first year of a number of comparatively large specimens of *Mugil cephalus* and a single specimen of *Pogonias cromis* weighing more than 1.2 kg.

7. The main effect of location shows a highly significant difference in total weight of fishes per collection and the location-by-season interaction is significant.

8. There is a highly significant difference between surf and tidal pool in average total weight of fishes per collection for winter and summer and a significant difference for spring.

9. Six species of fishes (*Anchoa mitchilli, Fundulus majalis, Menidia menidia, Trachinotus carolinus, Menticirrhus littoralis*, and *Mugil curema*) accounted for 94% of the specimens of fishes collected and 72% of the ichthyomass. One species, *Arenaeus cribrarius*, made up 82% of the swimming invertebrate specimens and 75% of the mass of swimming invertebrates.

10. Species were ranked as to "importance." In the surf and tidal pool combined the order of decreasing "importance" for the most abundant species was *Menidia menidia, Arenaeus cribrarius, Trachinotus carolinus, Menticirrhus littoralis* and *Mugil curema, Anchoa mitchilli*, and *Fundulus majalis*.

11. Water temperature and its square correlated significantly with number of specimens for each of five of the most important species (*Arenaeus cribrarius, Anchoa mitchilli, Menidia menidia, Trachinotus carolinus*, and *Menticirrhus littoralis*) collected in the surf. Height of sea was significantly correlated with occurrence for *A. mitchilli* and *M. littoralis*; and a significant negative correlation existed between salinity and number of specimens for *M. menidia*.

12. The prediction equation for monthly average number of specimens per collection contained water temperature, the square of water temperature, and salinity as independent variables for *Menidia menidia*, but only water temperature appeared in the equations for all other species examined except *Anchoa mitchilli*, which contained visibility of Secchi disc (in addition to water temperature) as an independent variable.

13. *Arenaeus cribrarius* has a prolonged spawning period; ovigerous females were collected as early as mid-June, recently spawned females as late as mid-September, and small specimens (20 mm CW or smaller) from May through October.

14. Ripe specimens of *Menidia menidia* were observed from late March to early June. Specimens of *M. menidia* 50 mm SL or smaller were rarely collected. Because this virtual absence of small individuals of *M. menidia* does not appear to be related to the method of collection, this species presumably occupies a habitat other than the surf zone during its early life history.

15. *Trachinotus carolinus* has a prolonged spawning period; specimens 22 mm SL or smaller appeared in the catch from mid-April through late October.

16. Specimens of *Menticirrhus littoralis* less than 30 mm SL were collected from June through November indicating an extended spawning period.

17. The apparent absence of juveniles of *Paralichthys squamilentus* in the waters of South Carolina before 1969 is a result for the most part of inadequate collecting.

18. *Sphoeroides spengleri* is reported for the first time from the waters of South Carolina.

19. Relationships of carapace length to carapace width and these measurements to weight are presented for the decapod crustacean *Arenaeus cribrarius*; and the relationships of lengths and lengths to weight are presented for eight species of fishes.

20. Recommendations for improving surveys similar to the one reported herein are given.

21. Stochastic effects seem to be important in determining the catch in the surf and associated tidal pools of sandy beaches.

22. Species inhabiting the surf zone must be able to cope with wide ranges in turbulence, turbidity, quantities of suspended particles in the medium, current velocity, and bottom characteristics. In addition to the above factors, a number of meteorological and seasonal changes are superimposed producing variations in temperature and salinity. Highly motile species may move into or out of the surf zone depending upon prevalent conditions. This may account in part for some of the variations in catch.

23. The macrofauna of the tidal pool is a depauperate derivative of the surf zone.

24. Species collected in the tidal pool were probably attracted there to some degree by their different ecological requirements and tolerances. In addition, larger individuals tend to avoid being trapped in these pools, whereas smaller ones (of species such as

Trachinotus carolinus and *Mugil curema*) may actively seek them as havens which are relatively free of predators. Species inhabiting tidal pools are subjected to sudden fluctuations in temperature and salinity.

ACKNOWLEDGMENTS

We are grateful to Thomas D. Bryce, Michael N. Cohen, Bruce A. Daniels, Charles H. Farmer, Donna Kim Harper, J. S. Hopkins, Mark B. Maddox, James F. McKinney, William A. Roumillat, and Barry Stamey for assistance in the field. Thomas D. Bryce, Charles H. Farmer, and James F. McKinney aided in numerous ways in processing some of the collections. Robert L. Shipp (University of South Alabama) identified the specimen of *Sphoeroides spengleri*. James F. McKinney and William A. Roumillat coded and checked data for the analyses by computer. B. M. Martin of the Department of Radiology, Medical University of South Carolina, made the radiographs used in this study. R. C. Duncan, C. B. Loadholt, and M. C. Miller, III, of the Department of Biometry, Medical University of South Carolina, provided assistance on statistical methods and access to computer facilities. This study was supported in part by a traineeship grant to James K. Dias from the Department of Health, Education and Welfare, Public Health Service, National Institutes of Health. Dale R. Calder (South Carolina Wildlife and Marine Resources Department, SCWMRD) verified the nomenclature used for invertebrates. Alice E. Charest, Karen R. Swanson, and Peter B. Laurie (all of SCWMRD) assisted with the manuscript preparation. Charles A. Barans (SCWMRD), Peter J. Eldridge (SCWMRD), C. B. Loadholt, John J. Manzi (SCWMRD), and John W. Tucker, Jr. (North Carolina State University) reviewed the manuscript.

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Migration and Dispersion of Tagged American Lobsters, *Homarus americanus*, on the Southern New England Continental Shelf

Joseph R. Uzmann, Richard A. Cooper, and
Kenneth J. Pecci

January 1977

U.S. DEPARTMENT OF COMMERCE
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Migration and Dispersion of Tagged American Lobsters, *Homarus americanus*, on the Southern New England Continental Shelf

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Kenneth J. Pecci

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Migration and Dispersion of Tagged American Lobsters, *Homarus americanus*, on the Southern New England Continental Shelf

JOSEPH R. UZMANN, RICHARD A. COOPER, and KENNETH J. PECCI [1]

ABSTRACT

An apparently contiguous stock of American lobsters, *Homarus americanus*, is concentrated along the outer continental shelf margin and slope from Corsair Canyon westward and southward to the region of Baltimore Canyon. Between April 1968 and May 1971 we captured, tagged, and released a total of 7,326 lobsters at 52 localities between Corsair Canyon and Baltimore Canyon. As of December 1972, 945 recaptures (12.9% recovery) had been reported, providing a basis for interpretation of seasonal and long-term movements, as well as measurements of growth rate and moult frequency. A classification scheme is developed and applied to distinguish between apparently directed seasonal movements (migrations), localized movements of less than 10 nautical miles (18.5 km), and long-period (>120 days) dispersions of 10 miles or more. This last category includes point to point tracks that cannot be objectively resolved in terms of directionality and may represent random dispersal, a summation of seasonally directed tracks, or both.

We conclude from the track analyses that at least 20% of the offshore lobsters annually engage in directed shoalward migrations in spring and summer with return to the shelf margin and slope in fall and winter. This conclusion is reinforced by independent analysis of the time/depth/temperature associations of tagged lobsters at recapture which, of itself, suggests that an even larger proportion of the offshore lobsters annually effect directed migrations in response to seasonal temperature variations.

INTRODUCTION

Commercial concentrations of American lobsters, *Homarus americanus*, inhabit the outer continental shelf and slope off southern New England and the Middle Atlantic states southward to Virginia. The history, development, and recent status of this resource have been summarized in the collective studies of Firth (1940), Schroeder (1955, 1959), McRae (1960), Hughes (1963), Saila and Flowers (1968), Skud and Perkins (1969), Uzmann (1970), and Cooper and Uzmann (1971). This report is an extension of the last mentioned paper and deals further with findings and implications of seasonal and long-term movements derived from an extensive tagging program conducted over the period 1968-72.

Schroeder (1959) defined the offshore lobster population as "a population of lobsters, large enough to support commercial fishing off the east coast of the United States along the outer shelf and upper slope between the eastern part of Georges Bank and the offing of Delaware Bay. This area at depths of roughly 60-250 fm (110-450 m) is about 400 miles long and 5-10 miles wide. Lobsters are more plentiful along the eastern half of this stretch than to the west and south."

The offshore lobster fishery, so-called, has rapidly assumed a role of prominence among the major offshore fisheries of the northwest Atlantic. A brief review of its growth over the past two decades will place it in perspective relative to the long established coastal fishery and indicate its future trend.

Like the coastal stocks from Maine to New Jersey, the offshore stock has sustained a steadily increasing rate of exploitation since the mid-fifties prior to which time it ranked as a minor fishery with the majority of catches taken incidental to trawling for groundfish species. Following World War II, the coastal fishery expanded rapidly to a peak yield in 1960 of 29 million pounds (13.2 million kg) and has since declined measurably despite increased fishing effort; meanwhile, offshore lobster catches increased from nearly 2 million pounds (0.9 million kg) in 1960 to over 8 million pounds (3.6 million kg) in 1970. Ungrouped landings statistics indicate that U.S. lobster production is relatively stable at some 30 million pounds (13.6 million kg) annually, but the fact of the matter is that offshore production has annually offset the decline of coastal landings. From 1968 to 1970 offshore lobster landings averaged over 20% of the U.S. catch.

MATERIALS AND METHODS

The tagging program reported here was conducted as part of the work plan of 14 research cruises over the period 1968-71 during which time a total of 7,326 lobsters were tagged and released at 52 localities along the outer edge of the continental shelf from Corsair Canyon west

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and south to Baltimore Canyon (Fig. 1, Table 1). The lobsters were taken with otter trawls or traps (five localities only) at depths of 35-300 fathoms (64-549 m), then tagged and released within a day after capture and within 2.7 nautical miles (5 km) of the capture site. Tagging methodology has been described previously by Cooper (1970). Essentially, the tag consists of coded polyvinyl chloride tubing with a polyethylene monofilament leader and stainless steel anchor implanted in the right or left dorsal extensor muscle below the carapace. The anchor is inserted with the aid of a hypodermic needle through the connecting membrane between the carapace and the first abdominal segment. The membrane breaks down at ecdysis to permit withdrawal of the lobster from the old exoskeleton and the implanted tag is thus retained through successive molts.

The tagging program and its objectives were initially well advertised with letters and poster notices being sent to all New England and Middle Atlantic state fisheries commissioners, to all vessel captains known to engage in the offshore lobster fishery, and to all major buyers and wholesalers of lobsters. Port agents of the National Marine Fisheries Service were specially briefed and then maintained continuing liaison with the lobster fishermen and dealers.

In a preliminary paper Cooper and Uzmann (1971) reported 400 returns from 5,710 releases through 1969 (7.0% reported recapture); in 1970 and 1971 additional releases raised the total number tagged and released to 7,326, of which a cumulative total of 945 recoveries had been reported to us as of 15 December 1972. Thus, the accumulated reported recaptures is currently 12.9% and increasing at a decreasing rate annually by virtue of natural mortality of the tagged population, tag loss, nonrecognition of tags, possible emigration into areas with little or no commercial fishery, removal and nonreporting by U.S. fishermen and various elements of the foreign fishing fleet, and possibly, increased incidence of nonreporting because of fishermen apathy. We offer the last theoretical reason because renewed publicity and an increase in the tag return reward from $1.00 to $5.00 in October 1971 failed to elicit a significant increase in the tag return rate despite a significant input (1,142) of newly tagged lobsters in that calendar year. This hypothesis is further supported by calculations of expected returns per annum under the condition of exponential decline of the

Table 1.—Summary of offshore lobster tagging, 1968-71: station references, releases, and recaptures.[1]

Year	Composite station number	Original station number(s)	Plot position		Canyon or shelf region	Number of releases	Number of recaptures
			Lat. N	Long. W			
1968	1	(1-3)	40°17′	68°02′	Oceanographer Canyon	42	3
	2	(4)	39°59′	69°36′	Veatch Canyon	13	3
	3	(5)	39°31′	72°13′	Hudson Canyon	146	9
	4	(6)	40°05′	71°09′	Block Canyon	52	7
	5	(7-8)	40°04′	70°27′	Atlantis Canyon	264	29
	6	(9, 11)	39°57′	69°56′	Veatch Canyon	149	22
	7	(10)	39°56′	69°41′	Veatch Canyon	99	10
	8	(12)	39°59′	70°03′	Veatch Canyon	50	4
	9	(13)	40°03′	70°17′	Atlantis Canyon	143	19
	10	(14)	40°13′	70°30′	Atlantis Canyon	39	3
	11	(15)	40°12′	70°15′	Atlantis Canyon	84	6
	12	(16)	40°12′	71°14′	Block Canyon	57	3
	13	(17-19)	40°05′	71°47′	Block Canyon	482	40
	14	(20-21)	40°05′	71°38′	Block Canyon	266	25
	15	(22)	41°42′	66°52′	Leg, Georges Bank	46	10
	16	(23-26)	40°33′	68°39′	SW Georges Bank	479	59
	17	(27-28)	40°31′	67°42′	Lydonia Canyon	223	27
Total						2,634	279
1969	18	(29, 30, 32)	39°59′	69°29′	Veatch Canyon	1,350	213
	19	(31)	40°03′	69°16′	Veatch Canyon	751	104
	20	(33-35)	40°59′	66°34′	Corsair Canyon	387	44
	21	(36)	40°32′	67°47′	Lydonia Canyon	166	23
	22	(37-38)	41°12′	66°35′	Corsair Canyon	422	46
Total						3,076	430
1970	23	(48, 50)	40°16′	68°25′	Oceanographer Canyon	301	34
	24	(49, 51)	40°26′	68°20′	Oceanographer Canyon	173	22
Total						474	56
1971	25	(57-58)	40°00′	71°12′	Block Canyon	60	10
	26	(59, 63)	39°14′	72°20′	Hudson Canyon	54	1
	27	(60-62)	37°55′	73°59′	Baltimore Canyon	194	11
	28	(64)	39°10′	72°38′	Hudson Canyon	29	3
	29	(65-66)	40°00′	69°29′	Veatch Canyon	805	155
Total						1,142	180
Grand Total						7,326	945

[1] The original releases are treated as 29; composites of two or more stations have within-group variation of less than 10 days, 10′ latitude, and 10′ longitude. Original station numbers are shown in parentheses.

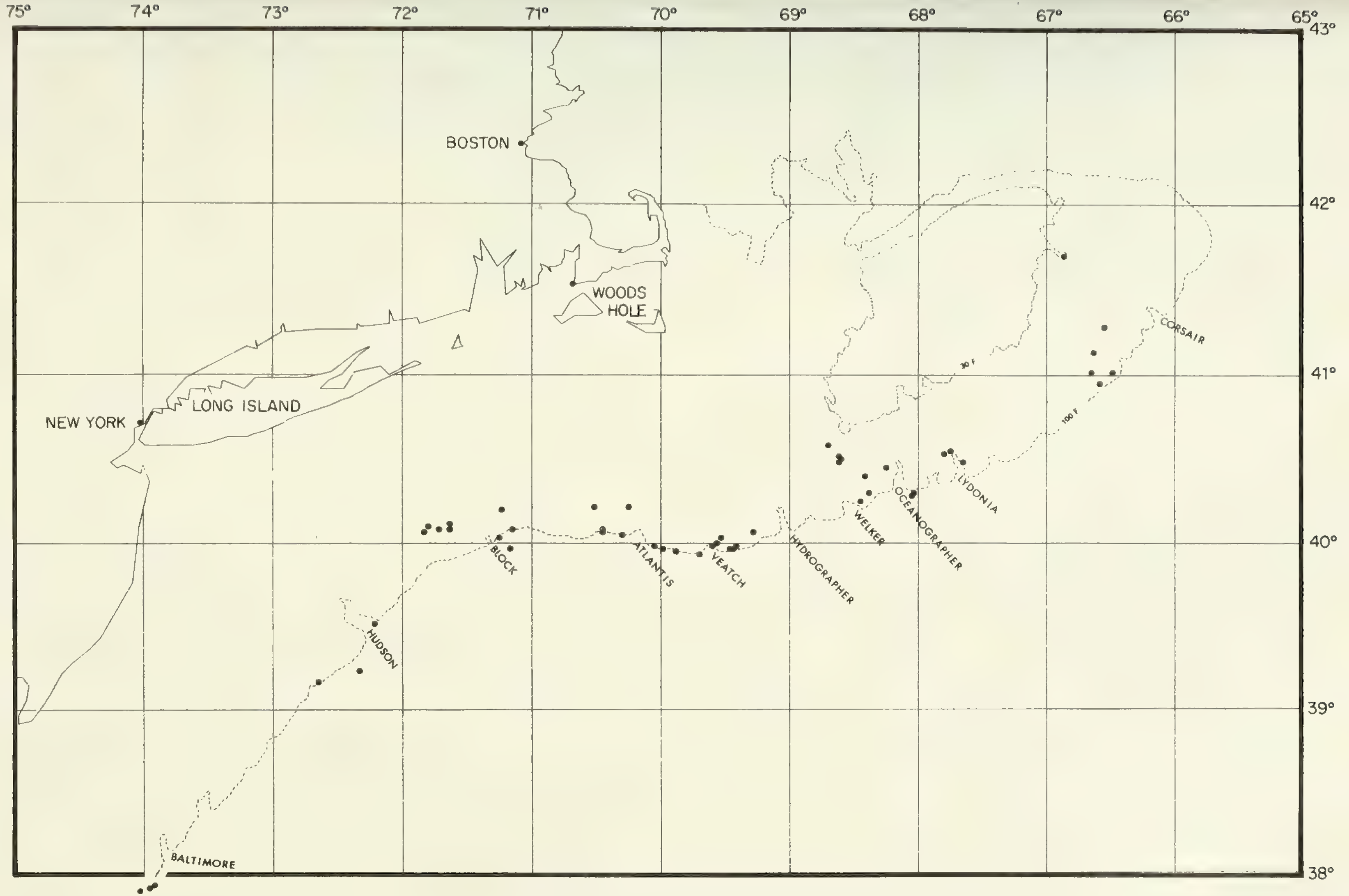


Figure 1.—Original station locations and nearby canyons.

tagged population at a theoretical summed rate of 23% per annum (12% tag loss, 6% natural mortality, 5% recapture). In calendar year 1972, for example, the theoretical number of tagged lobsters outstanding at the beginning of the year was 3,630; the expected number of returns for 1972 based on the average rate of returns (0.049) in years 1968-71 is 179, in sharp contrast to 67 actual returns.

The distribution of recaptured tagged lobsters is considered representative of the distribution of the lobster population. Fishermen search for commercial quantities of lobsters throughout the year at depths of 10-350 fathoms (18-640 m), which is a considerably greater range than the 35-300 fathoms (64-549 m) depth interval from which lobsters for tagging were initially captured.

DATA REDUCTION, PLOTTING, AND FORMAT

Data received on individual recaptures varied considerably. Data sought included date and position of recapture (latitude and longitude, or loran A coordinates), sex, carapace length, presence or absence of external eggs, cheliped configuration, and designation of any missing chelipeds and walking legs. The most critical data were location and date of recapture, and carapace length from which both migration trends and growth could be determined; this was received on 350 of the recaptured lobsters. Recapture location and date only were received on 576 individuals and provide the basis for analysis of movements.

Data was listed and keypunched in two different formats. The data format (see appendix tables) for this study includes growth increments for reader reference, but this element of the study is being treated separately; return data is listed chronologically by sex. The basic data deck provided input for computer calculation for individual recaptures of great circle distance traveled from point of release to point of recapture, days at large, and other standard computations such as mean distance traveled and mean time at large by various groupings of individuals. The same data deck served as input for a Cal-Comp Plotter, Model 663, from which release coordinates, recapture coordinates, or combinations of both were plotted in various combinations to reveal and display the overall features of dispersion within and between release groups and to show the overall monthly distribution of recaptures. The Cal-Comp Plotter was simultaneously programmed and fed a series of coastline coordinates, isobath coordinates, and titular information such that the finished plot was a Mercator chart drawing to the nominal scale of 1:1,200,000.

Among the 945 recaptured lobsters, 584 (61.8%) were reported by specific location, 183 (19.4%) by generalized location—usually by reference to a named submarine canyon, and 178 (18.8%) without location information of any kind. Those recaptures reported by approximate location are hand-plotted in distinctive fashion within the machine plots of the various subgroups of returns with specific location.

In order to facilitate interpretation of recovery data, we have treated the 52 original releases as 29 according to the constraints footnoted in Table 1. This action minimized the plotter executions and gave more coherence to the individual plots. Test plots of recovery coordinates showed a number of cases where overplotting or tight grouping of recovery points resulted in a confusion of points and numbers. In these instances we used a plotting subroutine which plotted all points within or upon the eastern and southern side of a given 6-minute square (0.1° square) as a single point with collective number at the diagonal center of the square; the average displacement of any single point plotted in this manner is well under 3 nautical miles (5.6 km) which we have accepted as within the limits of navigational accuracy, reporting, or both.

Because the tag releases were effected in greater or lesser increments over a long period of time, they constitute a series of repetitive experiments and are treated accordingly; the overall presentation which follows takes the form of an atlas which provides a pictorial analysis of the results of the various releases. Additionally, we have developed a generalized treatment of the monthly distribution of offshore lobsters in relation to bottom temperature.

Original Station Locations

A total of 52 releases of tagged lobsters were made on the outer continental shelf and slope commencing in March 1968 and ending in May 1971 (Table 1). Cruise numbers and station numbers are not wholly in consecutive order because interim cruises involving coastal area tagging were also conducted in the same period. Thus, station 66 occupied during Cruise 20 was actually the 52nd and last release during a total of 14 cruises concerned with offshore tagging.

The original release localities (Fig. 1) show their location relative to major features of the continental shelf and to each other. Most (86%) of the tagging was accomplished from the vicinity of Block Canyon eastward because of more productive lobster fishing in these areas and because other aspects of cruise objectives required cruise orientation to the east of Block Canyon to maximize time sharing of the research vessels *Delaware I*, *Delaware II*, and *Albatross IV*.

Composite Station Locations

Thirteen (25%) of the 52 original releases are plotted at their original release locality (Fig. 2). The remainder were combined in groups of two or three and assigned location coordinates with averaged latitude and longitude rounded to the nearest whole minute (Table 1). Maximum distance between any two original release sites comprising a composite station was 4 nautical miles (7.4 km). The purpose of this treatment was to effect a logical pooling of release and recapture information that would expedite both plotting and evaluation of the data. Computations of distance traveled and time at large are,

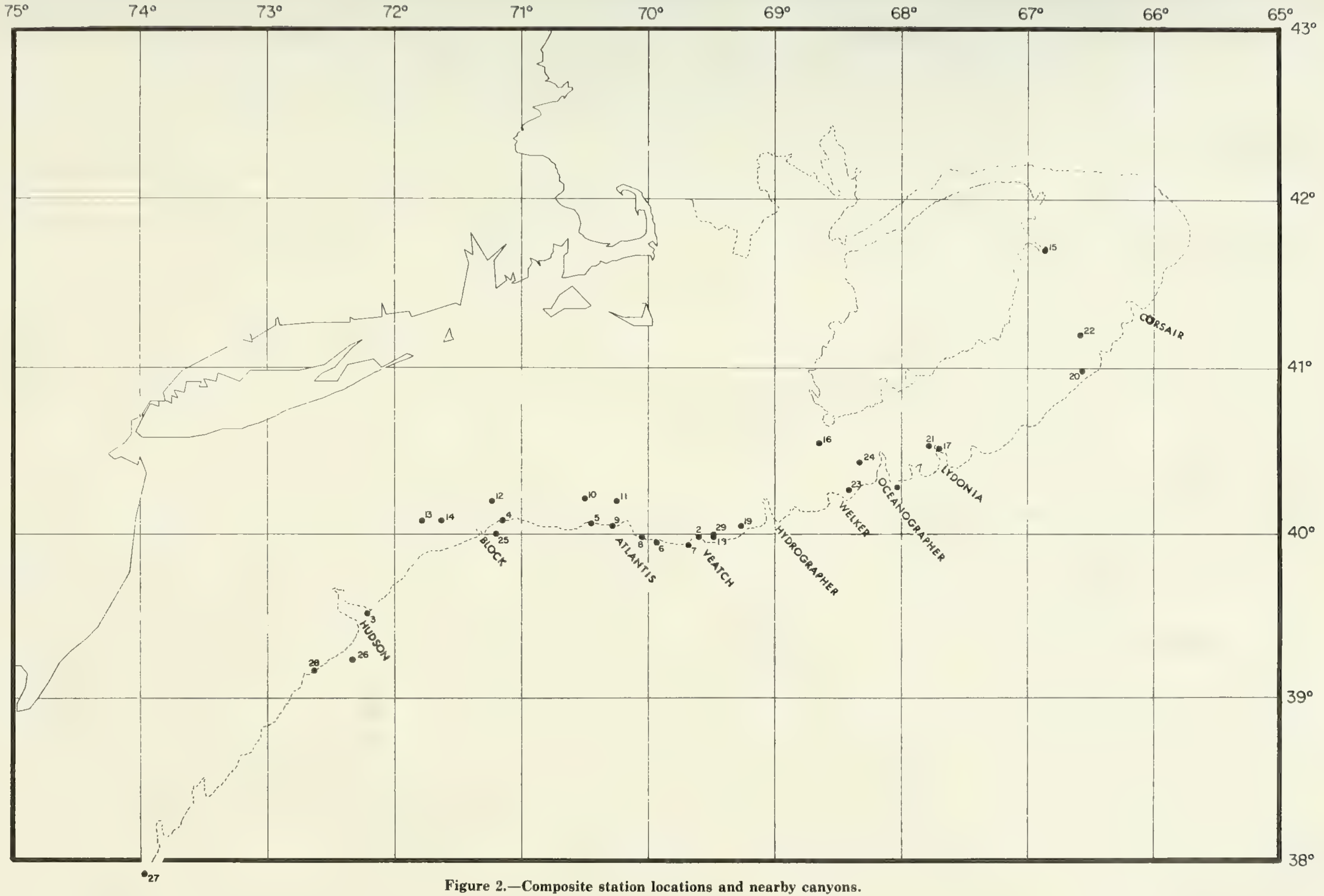


Figure 2.—Composite station locations and nearby canyons.

however, based on original release locations and dates. Details concerning individual recaptures are referenced to composite station number and listed in the appendix tables of this report.

Composite of Recoveries

Figure 3 is a precision plot of the reported recovery positions of all returns; in Figure 4 the same set of coordinates are grouped by 6-minute squares to permit readable numerical signature and to obviate overplotting of identical recovery coordinates, some of which occurred by chance, with others the result of multiple recaptures by vessels fishing a given area for one or more days.

Comparison of Figure 3 with Figure 1 (original station locations) shows overall dispersion from the original release locations along the edge of the continental shelf. Replotting of these data by release groups (Figs. 5-29) illustrates the magnitude and direction of the individual dispersions.

Straight-line dispersion (point of release to point of recovery) of individual lobsters is shown in Figures 5-29; concentric circles having a radius of 10 and 50 nautical miles (18.5 and 92.7 km) are drawn about each release locality to indicate the magnitude and variability of lobster movements from a given locality. Track lines of 50 miles (92.7 km) or greater are labeled with the return number and sex (F or M). Where two or more recaptures were made at the same reported locality, the solid circle representing the recovery point is appropriately numbered. In several instances (Figs. 20, 21, 24, 29) it was necessary to group recovery data by 6-minute squares for reasons described previously; in such cases, the nature of the plotting is included in the figure title.

Definition of Lobster Maturity

Subsequent references to maturity stage of individual lobsters assumes that the commonly prevailing minimum legal size (81 mm carapace length) is an acceptable beginning point at which both male and female lobsters attain functional sexual maturity. Skud and Perkins (1969) reported that demonstrable sexual maturity, as evidenced by external embryonated eggs or mature ovarian eggs, commenced at 80 mm carapace length in large samples of female lobsters from the same areas in which we conducted our tagging study. Stewart (1972) examined 1,018 female lobsters from western Long Island Sound and Block Island Sound for presence of spermatophores in the seminal receptacle; the median size of inseminated females in the sample (size range 53 to 106 mm carapace length) was 76 mm, and within the size class 81-82 mm (53 specimens), 81% were inseminated. Krouse (1973) found that male lobsters from the Boothbay region of Maine were virtually all sexually mature well below the legal recruit size of 81 mm; these findings were based on dissection of the genital tracts and microscopic findings of mature sperm cells and spermatophores; Krouse (1973) reiterated the observations of Templeman (1934) that significant size disparity between male and female lobsters precludes successful mating and that prerecruit size males seem unlikely to contribute materially to natural reproduction until they attain a size equality with sexually mature females.

MIGRATION VERSUS DISPERSION

Cooper and Uzmann (1971) earlier hypothesized, on the basis of a described time-temperature relationship, that the nature of the migration phenomenon was a vernal shoalward movement to warmer water with subsequent return to the edge and slope of the shelf with the onset of fall and winter. In subsequent sections of this report we will attempt to elicit qualitative and quantitative aspects of individual movements from groupings of individuals referenced to release locality, point of recapture, and time at large.

Hypothetical track lines have been drawn in all cases where dispersion or migration (definitions presented below) from point of release to point of recapture exceeded 10 nautical miles (18.5 km) (Figs. 5-29). We must concede at the outset of this discussion that the magnitude, direction, and time scale of a point-to-point track is seldom an accurate portrayal of the exact movements of any tagged animals; however, the assumption of a straight-line track, however simplistic, is tenable for the purposes of plotting, overview, analysis, and ultimately, for distinction between the short-term probable migrants and the longer-term dispersed individuals. The guiding factors in this distinction of kinds, i.e., migrant or dispersed, are distance traversed and time at large, the elements of the classical ground speed formula D/T.

Ranking of the total array of recovery data by various combinations shows that the maximum movement of any recapture was 186 nautical miles (345 km) in 71 days (2.6 miles/day). Other sesonable tracks in excess of 100 miles (185 km) were 125 (232 km)/86 days, 123 (228 km)/76 days, 118 (219 km)/107 days, 111 (206 km)/108 days, and 102 (189 km)/29 days. Twelve other lobsters made apparently directed tracks of 50-87 miles (93-161 km) within 22-41 days. The calculated ground speeds of these 31 examples range from 1 to 5.5 miles (1.8-10.2 km) per day and indicate that directional movements in excess of 1 mile (1.8 km) per day are not uncommon if not, in fact, quite normal.

We have developed a classification scheme which attempts to distinguish between directed migrants and those whose net movements over time are inconsequential or not clearly directional; the 31 examples cited above provide a logical basis for fixing constraints on the numerical values of time and distance consistent with an acceptable definition of the term "migrant."

The frequency distribution of distance traveled shows that 163 individuals were recovered within 0-9 miles (0-16.8 km) of point of release over the time range 0-950 days. Clearly, there is no internal evidence that any of these have dispersed significantly. In the time frequency interval 0-9 days, 15 of 21 recoveries were common to the

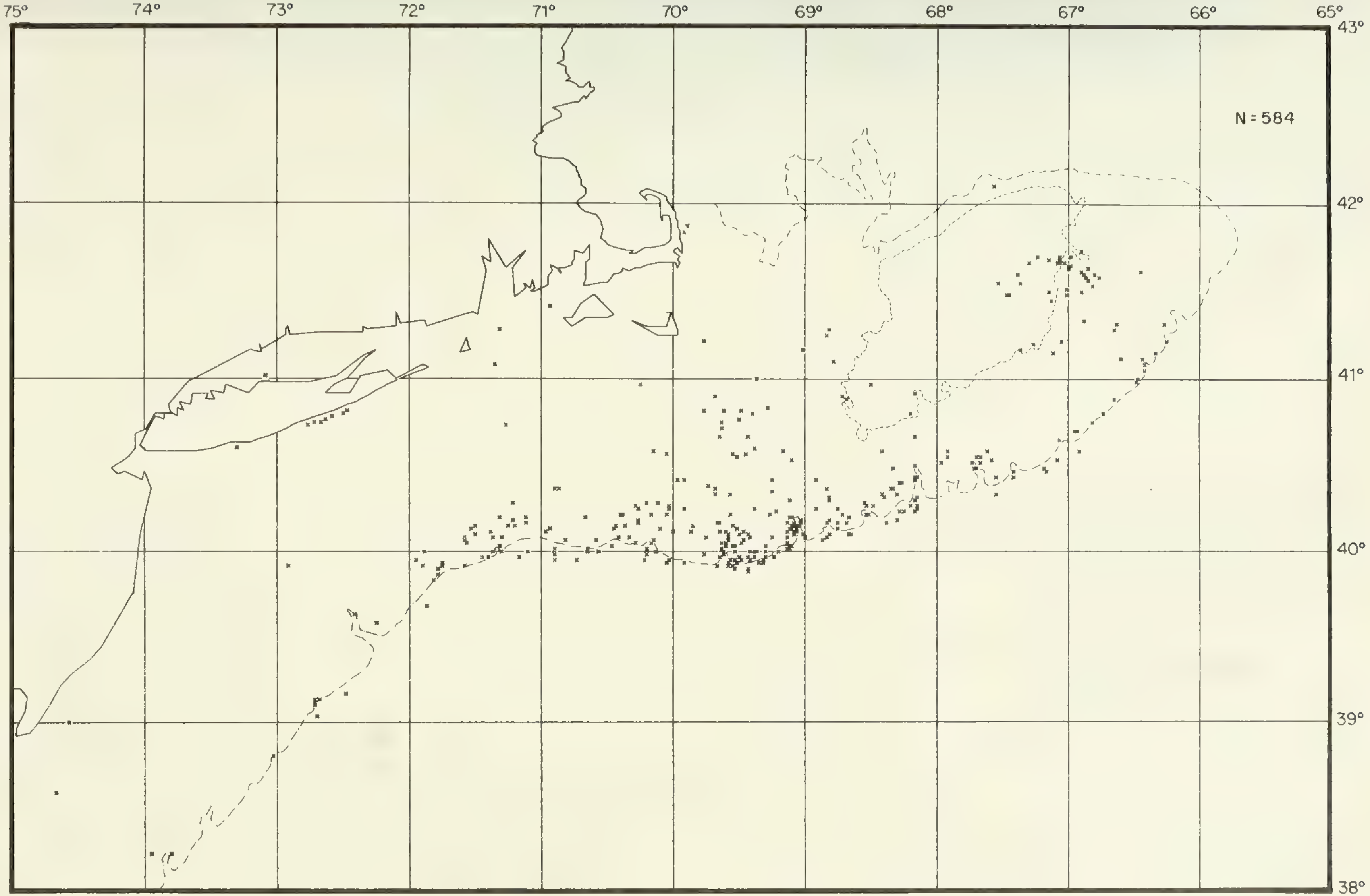


Figure 3.—Composite of tagged lobster recoveries, 1968-72.

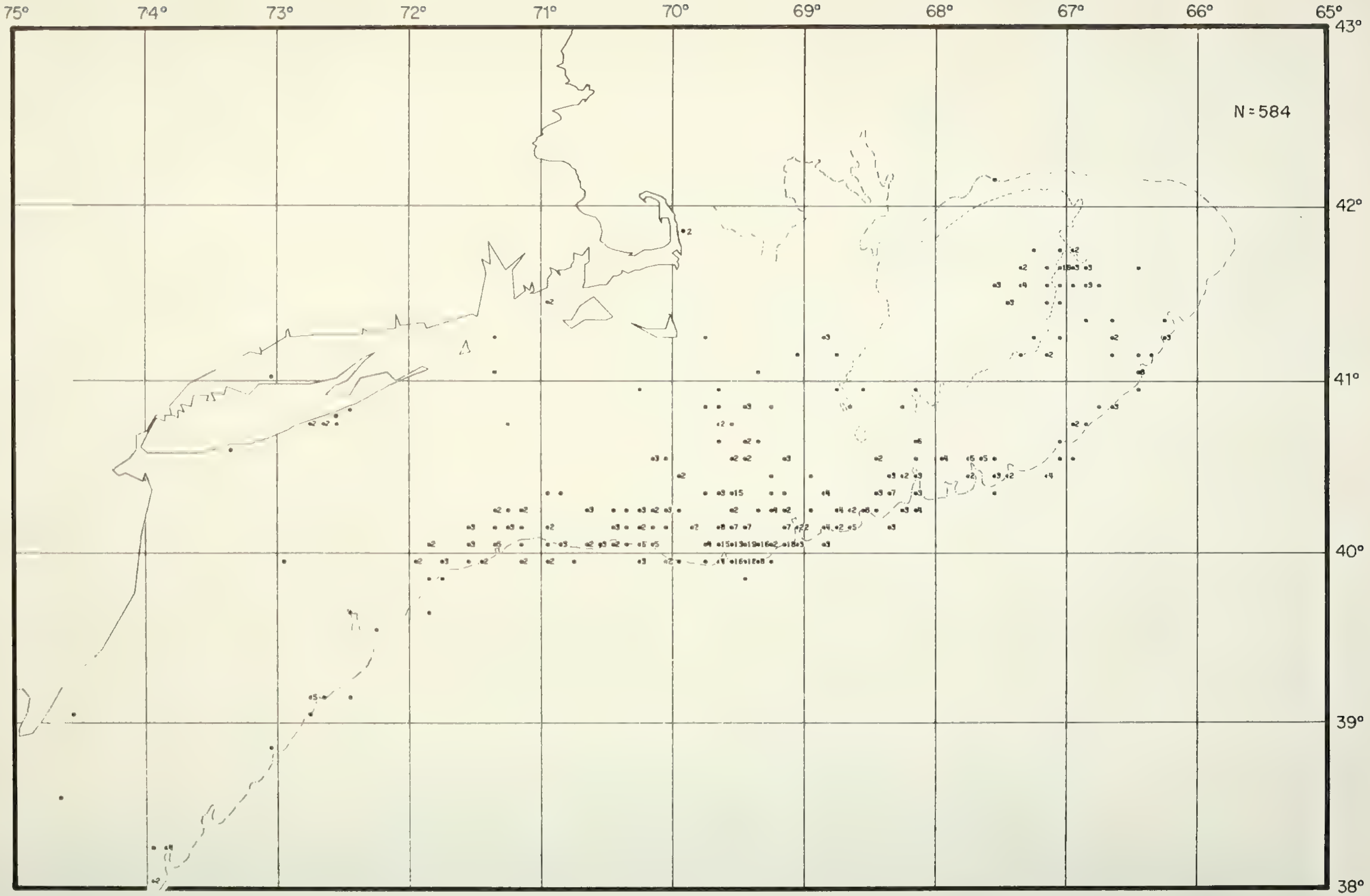


Figure 4.—Composite of tagged lobster recoveries grouped by 6-minute squares, 1968-72.

aforementioned 0.9 mile (0.16.8 km) category. Accordingly, we have adopted the premise that time or distance values under 10 preclude realistic interpretation of directionality or speed of movement.

Commercial fishing effort, monthly distribution patterns of tagged recoveries (Figs. 34-45), and supporting details (appendix tables) all combine to show that offshore lobsters are essentially aggregated along the outer edge and slope of the continental shelf during January through April (120 days) and become widely dispersed by migration or random movement in shoaler/warmer water during May through December (245 days). We have set the upper limit of duration of a directed migration at 120 days, or the theoretical half-life of a migratory season during which the migrant can move to shoaler/warmer water and return to the continental shelf margin in approximate phase with the annual shoalward and seaward migration of the bottom temperature warm front (here defined as the 10°C isotherm). Within these constraints we regarded a total of 117 individuals as migrants; ranking of these individuals by calculated ground speed shows a range of 0.1-5.5 miles (0.18-10.2 km) per day, a median speed of 0.9 miles (1.7 km) per day, and a median at 0.6 miles (1.1 km) per day. Ground speeds of defined migrants are positively correlated with distance traversed and negatively correlated with time at large.

The remainder of recaptures for which capture location and time at large are known fall into three categories of relative displacement from point of release. Our working definitions of migrant and alternative classifications are as follows:

a) Migrant by virtue of track $\geq$10 nautical miles (18.5 km) and time at large 10-120 days (N = 117).

b) Nonmigrant by corollary definition of track $<$10 miles and time at large $<$10 days (N = 15).

c) Residual nonmigrant by virtue of track $<$10 miles, time at large $\geq$10 days (range 15-950); this classification reflects stationary behavior, or the alternative possibility of undetectable excursion(s) with homing back to release locality (i.e., within 10-mile radius of release point) (N = 147).

d) Indeterminate by virtue of track $\geq$10 miles (range 10-181), time at large $>$120 days (range 125-1,549); movement is regarded as random dispersal, a summation of migration tracks, or a combination of both (N = 297).

Eight recaptures were reported without dates of recapture and hence could not be classified. These alternative classifications make for interesting conjecture in many cases; among the indeterminates, for example, we find many probable examples of directed migration which cannot be properly assessed because of the associated element of excessive time at large; these cases will be identified and discussed under the appropriate composite station résumés which follow this section.

Returning to the reliability of ground speed calculated from D/T, we have assumed that D is probably underestimated in most cases because a lobster track of significant distance over the bottom is unlikely to be straight-line, and also because some of the recaptures were likely on a return course relative to their original shoalward vector. Conversely, T is probably overestimated (but never underestimated) in a majority of cases because the migrant under consideration had 1) earlier arrived at destination, 2) had accumulative rest periods, and/or 3) was on a return vector. The net effect of any or all of these possible biases on calculated ground speed is to underestimate the derivation in general and to give added credence to values on the order of 4-5 miles (7.4-9.3 km) per day.

COMPOSITE STATION RÉSUMÉS

Composite Station 1 (See Appendix Table 1)

Three recaptures have been reported from a composite total of 42 releases in the vicinity of Oceanographer Canyon on 15 March 1968 (28), 16 March 1968 (5), and 30 March 1968 (9). Mean depth at first capture was 153 fathoms (280 m); mean depth at release was 175 fathoms (320 m). Only one of the recoveries was reported by location. The sex ratio of the three returns was one female to two males.

The most noteworthy feature of the recoveries from this composite release is the relatively high mean time at large (985 days =2.7 yr) which exceeds that of all other subgroups of recoveries. The single located recovery, a mature male, was captured 13 miles (24.1 km) from its original release point and had been at large 1,342 days (3.7 yr).

Here, as in many other cases of lengthy time at large, the relatively small displacement from original release locality is indicative of either highly localized movements over time or, alternatively, a homing tendency following larger scale movements. We prefer the latter hypothesis and will attempt to sustain this view in the remainder of the text on the basis of other individual and collective returns.

Composite Station 2 (See Figure 5 and Appendix Table 2)

Three recaptures, all males, have been reported from a single point release of 13 lobsters near the head of Veatch Canyon on 4 April 1968. First capture depth and release depth were at 110 fathoms (201 m). Two of the recaptures were reported by location with neither having migrated very far nor having been at large very long. The third recapture, a mature male, had been at large 741 days (2.0 yr), and was reported taken in the vicinity of Veatch Canyon without specific coordinates.

This subgroup of recoveries represents the highest rate of recapture (23%) among the 29 subgroups of releases and indicates that numerically small releases of tagged lobsters can yield significant returns.

Composite Station 3 (See Figure 6 and Appendix Table 3)

Nine recaptures have been reported from a single point release of 146 lobsters on the east side of Hudson Canyon on 26 April 1968. First capture depth was 160 fathoms (293 m); release depth was 85 fathoms (155 m). Seven of the nine recaptures were reported by location and one other from the vicinity of Hudson Canyon. Sex ratio of the nine recaptures was seven females to two males. Mean time at large was 252 days (0.7 yr). Two of the recaptures (3F, 29F) from this release, both mature females, are classified as migrants and were captured 29 and 118 days later in coastal trap fisheries off Long Island, N.Y., after having migrated 102 miles (189 km) and 77 miles (143 km), respectively. The longest outstanding recapture (660 F), an immature female at release, was at large 1,024 days (2.8 yr) during which time it increased 32% in carapace length, which is indicative of at least two moult increments (Cooper and Uzmann 1971).

Three of the recoveries (3F, 29F, 4F) were migrants within the terms prescribed in the preceding section. Return 3F was recaptured 29 days after release following a 102-mile (189-km) migration to shoal water, at 3.5 miles (6.5 km) per day. Return 29F, on the other hand, showed a net displacement of 77 miles (143 km) over the much longer period of 118 days; the calculated speed of 0.6 miles (1.1 km) per day is well below the mean speed of the collective 117 defined migrants and inconsistent with an idealized ongoing shoalward track. In the absence of any contradictory evidence, it seems logical to conclude that this individual and others, as will be seen, probably arrived in the vicinity of their recapture at considerably earlier dates. Return 11F was recaptured 13 miles (24.1 km) northwesterly in slightly deeper water than at release.

Composite Station 4 (See Figure 7 and Appendix Table 4)

Seven recaptures have been reported from a single point release of 52 lobsters several miles east of Block Canyon on 28 April 1968. First capture depth was 190 fathoms (347 m); release depth was 100 fathoms (183 m). Four of the seven recaptures were reported by location. Sex ratio of the seven recaptures was three females to four males. Mean time at large was 425 days (1.2 yr). One of the four located recaptures, a mature male, moved 71 miles (132 km) easterly over a period of 405 days at large. The longest outstanding recapture (location unreported) in this subgroup was at large 1,326 days (3.6 yr).

Composite Station 5 (See Figure 8 and Appendix Table 5)

Twenty-nine recaptures have been reported from a composite total of 264 releases west of Atlantis Canyon on 29 March 1968 (142) and 30 March 1968 (122). Mean depth at first capture was 190 fathoms (347 m); mean depth at release was 99 fathoms (181 m). Twenty of the recaptures were reported by specific location and one by approximate location.

Sex ratio of the returns was 22 females to 7 males, not significantly different from the ratio at release (212 females to 52 males).

Mean time at large for all recoveries was 284 days (0.8 yr); greatest time at large for a located individual was 774 days (2.1 yr) during which time apparent dispersion was only 10 miles (18.5 km).

Mean distance traveled by those lobsters with specific recapture locations (20) was 25.1 miles. Three individuals, all sexually mature females, made migrations in excess of 50 miles (92.7 km), the range being 56-76 miles (104-141 km).

Four of the recoveries (28F, 26F, 27F, 4F), all mature females, are classified migrants; all were recaptured in June within 36-50 days after tagging. Return 28F, an egg-bearing female at release and recapture, was taken 56 miles (104 km) northeasterly in significantly shoaler water (22 fathoms = 40.2 m) after 50 days at large; apparent speed (1.1 miles/day = 2.0 km/day) and direction are highly consistent with the vernal shoaling hypothesis.

Returns 26F and 27F (egg-bearing at release and recapture) were taken 38 miles (70.4 km) easterly near the head of Veatch Canyon at 80 fathoms (148 m) after being at large 36 and 37 days, respectively; apparent speed in each case was 1.1 miles/day (2.0 km/day). It is obvious that these tracks are not consistent with a theoretical goal of shoaler location; we will reserve comment on these and others of similar nature for later discussion. Return 4F was taken 11 miles northeasterly in significantly shoaler (64 fathoms = 117 m) water; this recovery illustrates quite well that lobsters occupying the shelf edge or slope can achieve much shoaler (or deeper) locations with relatively small excursions.

Composite Station 6 (See Figure 9 and Appendix Table 6)

Twenty-two recaptures have been reported from a composite total of 149 releases midway between Atlantis and Veatch canyons on 1 May 1968 (78) and 2 May 1968 (71). Mean depth at first capture was 190 fathoms (347 m); mean depth at release was 99 fathoms (181 m). Nineteen of the recoveries were reported by specific location and one by approximate location. Sex ratio at release was 103 females (69%) to 46 males; the ratio at recapture was 12 females (55%) to 10 males.

Mean time at large for all recoveries was 312 days (0.9 yr); greatest time at large for a located individual, an immature male at release, was 896 days (2.4 yr) during which time apparent dispersion was only 18 miles (33.4 km).

Mean distance traveled by those lobsters with specific capture locations (19) was 33.5 miles (62.1 km). Five individuals made migrations in excess of 50 miles (92.7 km), the range being 57-71 miles (106-132 km). Three of these long distance migrants were mature females, one of which (91F) was berried at recapture; the remaining two were mature males.

Six of these recaptures (9F, 10F, 1M, 18F, 19F, 20M) can be classified as migrants. Recoveries 9F and 10F moved easterly, with the latter being taken significantly shoaler (56 fathoms = 102 m) than at release. Return 1M migrated at near record speed of 5.1 miles (9.4 km) per day to a point 62 miles (115 km) westerly at a depth (120 fathoms = 219 m) significantly deeper than at release. The release depth here, as at a number of other stations, was significantly shoaler than release depth for reasons explained earlier; it is conceivable, therefore, that bottom temperature at the release site was sufficiently divergent to cause abnormal behavior. Returns 18F, 19F, and 20M were recaptured at the same point in time and space after 49 days at large; their recovery position was 18 miles (33.4 km) easterly in shoaler (69 fathoms = 126 m) water.

Composite Station 7 (See Figure 10 and Appendix Table 7)

Ten recaptures have been reported from a single point release of 99 lobsters on the west side of Veatch Canyon on 2 May 1968. Mean depth at first capture was 200 fathoms (366 m); mean depth at release was 100 fathoms (183 m). Eight of the recaptures were reported by specific location. Sex ratio at release was 77 females (77%) to 22 males; the ratio of the returns was 7 females (70%) to 3 males.

Mean time at large for all recoveries was 477 days (1.3 yr); greatest time at large for a located individual, a mature female, was 771 days (2.1 yr). This individual was recaptured 58 miles (107 km) north of the point of release in June 1970; its location in time and space is consistent with a working hypothesis of seasonal shoaling and return to home locality.

Mean distance traveled by those lobsters with specific capture locations (8) was 29.3 miles (54.4 km). Two individuals qualified as long migrants; one of these was the mature female noted above while the other was a mature male.

Among the eight located recaptures, only one (8M) is a defined migrant and is consistent with the springtime shoaling hypothesis; this individual ranged shoalward from 100 to 63 fathoms (183-115 m) at a net speed of 1.8 miles (3.3 km) per day.

Composite Station 8 (See Figure 11 and Appendix Table 8)

Four recaptures have been reported from a single point release of 50 lobsters on the east side of Atlantis Canyon on 14 June 1968. Mean depth at first capture was 70 fathoms (128 m); mean depth at release was 86 fathoms (157 m). Two of the recoveries were reported by specific location and one by approximate location. Sex ratio at release was 30 females (60%) to 20 males; the ratio at recapture was 1 female to 3 males.

Mean time at large for all recoveries was 386 days (1.1 yr); greatest time at large for a located individual, a mature male, was 734 days (2.0 yr), during which time apparent dispersion was 26 miles (48.2 km).

Maximum dispersion was attained by 156M, a mature male, which was recaptured 114 miles (211 km) easterly near the head of Lydonia Canyon. A third individual, a mature female, was reported from the vicinity of Hudson Canyon, some 100 miles (185 km) westerly of release.

Composite Station 9 (See Figure 12 and Appendix Table 9)

Nineteen recaptures have been reported from a single point release of 143 lobsters on the west side of Atlantis Canyon on 15 June 1968. Mean depth at first capture was 70 fathoms (128 m); mean depth at release was 100 fathoms (183 m). Thirteen of the recaptures were reported by specific location and two by approximate location. Sex ratio at release was 72 females (50%) to 71 males; the ratio at recapture was 11 females (58%) to 8 males.

Mean time at large for all recoveries was 623 days (1.7 yr); greatest time at large, and record high overall, for a located individual (946M), a mature male at release, was 1,549 days (4.2 yr). This individual was recaptured 118 miles (219 km) easterly at Lydonia Canyon and had increased 63% in carapace length by virtue of at least three molts.

Mean distance traveled by those lobsters with specific capture locations (13) was 36.1 miles (66.9 km). Three individuals, a mature female, an initially immature male, and the mature male cited above, surpassed the 50-mile (92.7-km) range from point of release.

Composite Station 10 (See Appendix Table 10)

Three recaptures have been reported from a single point release of 39 lobsters some 15 miles (27.8 km) northeasterly of Atlantis Canyon on 16 June 1968. Mean depth at first capture was 90 fathoms (165 m); mean depth at release was 60 fathoms (110 m). All recaptures were reported by specific location. Sex ratio at release was 25 females (64%) to 14 males; the ratio at recapture was 2 females to 1 male, all being sexually immature.

Mean time at large (48 days) and mean distance traveled (14 miles = 25.9 km) were lowest and second lowest, respectively, among all subgroups of returns. The low rate of return, and particularly the disappearance of the group after only 60 days at large, suggests that unusually high mortality occurred shortly after release.

Two of the three recoveries (34F, 41F) are migrants by definition; both were immature females and were taken only slightly shoaler than release depth. The directionality of these tracks, as with many others among the defined migrants, has not resulted in maximum shoaling for distance traversed; it seems plausible, however, that those individuals, especially immatures, captured and released well up on the shelf as late as June might, in the main, have already completed a migratory transition from colder slope water to the seasonably warmer shelf water prior to recapture. An extension of this reasoning suggests further that others captured and tagged at these midshelf depths were still en route to shoaler grounds (e.g., recapture 25F discussed under subsequent account of composite station 13).

Composite Station 11 (See Figure 13 and Appendix Table 11)

Six recaptures have been reported from a single point release of 84 lobsters 7 miles (12.9 km) north of Atlantis Canyon on 16 June 1968. Mean depth at first capture was 60 fathoms (110 m); mean depth at release was 55 fathoms (101 m). All of the recaptures were reported by specific location. Sex ratio at release was 47 females (56%) to 37 males; the ratio at recapture was 5 females (83%) to 1 male.

Mean time at large for all recoveries was 361 days (1.0 yr). Greatest time at large was 727 days (2.0 yr); the individual involved was an immature female at release and one of two females in the subgroup of returns which surpassed the 50-mile (92.7-km) range of dispersion from release point. Mean distance traveled by the six recoveries was 32.2 miles (59.7 km).

Composite Station 12 (See Figure 14 and Appendix Table 12)

Three recoveries have been reported from a single point release of 57 lobsters 10 miles (18.5 km) northeast of Block Canyon on 16 June 1968. Mean depth at first capture and at release was 60 fathoms (110 m). All three recaptures were reported by specific location. Sex ratio at release was 25 females (44%) to 32 males; the ratio at recapture was 1 female to 2 males.

Mean time at large for all recoveries was 231 days (0.6 yr); greatest time at large was 358 days (1.0 yr) during which time the record individual, a mature male at release, traveled 52 miles (96.4 km) east to the east side of Veatch Canyon. Mean distance traveled by the three recoveries was 30.3 miles (56.2 km).

Composite Station 13 (See Figure 15 and Appendix Table 13)

Forty recaptures have been reported from a composite total of 482 releases west of Block Canyon on 18 and 19 June 1968. Mean depth at first capture was 60 fathoms (110 m); mean depth at release was 47 fathoms (86 m). Twenty-three of the recaptures were reported by specific location and three by approximate location. Sex ratio at release was 256 females (53%) to 226 males; the ratio at recapture was 25 females (62%) to 15 males.

Mean time at large for all accountable (37) recoveries was 484 days (1.3 yr); greatest time at large for a located individual, a mature female at release, was 1,360 days (3.7 yr). This individual was recaptured 72 miles (133 km) southwest from point of release.

Mean distance traveled by those lobsters with specific capture locations was 52.1 miles (96.6 km), the record high average for all subgroups of returns. Twelve individuals surpassed the 50-mile (92.7-km) range; additionally, three others were reported from the vicinity of Veatch Canyon which is well beyond the 50-mile (92.7-km) range from point of release. A disproportionate number (12/15) of the long-distance migrants were females; most of the females were sexually mature at release and all were sexually mature at recapture.

Two females were recaptured in the coastal trap fishery off southern Long Island, N.Y. One of these (25F) was berried at release and at recapture after having migrated 75 miles (139 km) in 28 days (2.7 miles/day = 5.0 km/day). The short term and long distance of this movement clearly supports an hypothesis of directed migration to warmer waters. The second female (335F) taken in the coastal zone was at large 465 days (1.3 yr) and, judging from its size at release, conceivably was engaged in a second or even third seasonal inshore migration.

Three recoveries (25F, 22F, 42M) are classified migrants. Return 25F, noted above, was recaptured in a local trap fishery at Fire Island Inlet, N.Y., in 7 fathoms (12.8 m) of water; vector and ground speed well exemplify the vernal shoaling concept. Return 22F was taken 14 days after release at a point 23 miles (42.6 km) southeasterly in slightly deeper water (60 fathoms = 110 m) than depth at release (47 fathoms = 86.0 m); it is significant, perhaps, that recapture depth and original capture depth were identical. We do not imply that this individual sought to return to original depth, but given a depth/temperature constant relationship over short term, it is conceivable that this lobster sought to return to its original temperature stratum. Return 42M, an immature male, was recaptured 58 days later and 47 miles (87.1 km) northeasterly in 50 fathoms (91.4 m) of water; considering immaturity and time of year, the net track would seem biologically unproductive.

Composite Station 14 (See Figure 16 and Appendix Table 14)

Twenty-five recaptures have been reported from a composite total of 266 releases 15 miles (27.8 km) northwest of Block Canyon on 20 June 1968. Mean depth at first capture was 60 fathoms (110 m); mean depth at release was 49 fathoms (89.6 m). Twenty-two of the recoveries were reported by specific location and one by approximate location. Sex ratio at release was 146 females (55%) to 120 males; ratio at recapture was 19 females (76%) to 6 males.

Mean time at large for all accountable (24) recoveries was 401 days (1.1 yr); greatest time at large for a located individual, a mature female at release, was 1,077 days (2.9 yr). This lobster (726F) was recaptured 181 miles (335 km) easterly near the head of Oceanographer Canyon; the hypothetical straight-line track is the penultimate distance record and is exceeded slightly by that of a mature female (249F) recaptured just off the north shore of Long Island, N.Y. (see Fig. 20).

Mean distance traveled by those lobsters with specific capture locations was 46.9 miles (86.9 km). Eleven individuals, fully half of the located returns, surpassed the 50-mile (92.7-km) range with a disproportionate number (9) being females. Four of the eleven, all females, were taken by a single fisherman in the seasonal trap fishery off southern Long Island; unfortunately, only the tag letter code and sex were reported and we are unable to correlate beyond date and original release station.

Among the 22 located recaptures, only one (33M) is a defined migrant; this individual moved southwesterly some 12 miles (22.2 km) and was recaptured at the same depth as at release.

Return 269M, and the four females mentioned above (347F, 348F, 349F, 350F) were taken approximately 1 yr after release in the southern Long Island trap fishery in 11-12 fathoms (20.1-21.9 m) of water; while not migrants in the strictly defined sense, these recaptures are special cases which probably represent directed migrations of the year (1969) in which captured.

Composite Station 15 (See Figure 17 and Appendix Table 15)

Ten recaptures have been reported from a single point release of 46 lobsters on the so-called Leg area of Georges Bank on 21 September 1968. Mean depth at first capture was 35 fathoms (64.0 m); release depth was 28 fathoms (51.2 m). Six of the recaptures were reported by specific location. Sex ratio at release was 23 females (50%) to 23 males; the ratio at recapture was 6 females (60%) to 4 males.

Mean time at large for all recoveries was 434 days (1.2 yr); greatest time at large for a located individual, a mature female at release, was 759 days (2.1 yr); this lobster apparently traveled only 12 miles (22.2 km), but it is evident from monthly distribution patterns developed later in this report that lobsters would not remain localized in this general area; time at large closely approximates an anniversary of the initial tagging event in this area and supports an hypothesis of seasonal revisitation to shoaler, warmer water.

Mean distance traveled by those lobsters with specific capture locations was only 16 miles (29.7 km); reference to Appendix Table 15 shows that five of the six accountable recoveries were taken 1 or 2 calendar years later during the warmest half of the year either at the shelf edge (548F), or relatively near the release area. The sixth (51F), taken in November, 44 days after release, was conceivably engaged in retreat from oncoming winter conditions to the warmer sanctuary of the shelf edge and slope. The high percentage (21.7) of recaptured lobsters from this release is second only to the slightly higher rate of recapture from Composite Station 2.

Composite Station 16 (See Figure 18 and Appendix Table 16)

Fifty-nine recaptures have been reported from a composite total of 479 releases near the southwest corner of Georges Bank on 24, 25, and 26 September 1968. Mean depth at first capture was 50 fathoms (91.4 m); mean depth at release was 40 fathoms (73.2 m). Thirty-nine of the recaptures were reported by specific location and eight by approximate location. Sex ratio at release was 196 females (41%) to 283 males; the ratio at return was 20 females (34%) to 39 males.

Mean time at large for all accountable (58) recoveries was 435 days (1.2 yr); greatest time at large for a located individual (932M), a mature male at release, was 1,407 days (3.8 yr).

Mean distance traveled by those lobsters with specific capture locations (39) was 34.8 miles (64.5 km). Nine individuals, the majority being mature, surpassed the 50-mile (92.7-km) range. Additionally, four others, two males and two females, were reported from the Veatch Canyon area, some 50 miles (92.7 km) from point of release. Maximum dispersion (107 miles = 198 km) from release point was achieved by an immature male (362M) while at large 411 days (1.1 yr).

Six of the 59 recaptures were migrants. Two of these (45F, 46M) were recaptured in October in slightly shoaler water; three (52F, 55F, 54M) were taken in November in slightly deeper (50 fathoms = 91.4 m) water, and one (75M) was taken the following January at a depth of 155 fathoms (284 m). Considering the respective dates of recapture, the tracks show a net tendency toward return to deeper water with the onset of winter season.

Composite Station 17 (See Figure 19 and Appendix Table 17)

Twenty-seven recaptures have been reported from a composite total of 223 releases near the head of Lydonia Canyon on 15 and 16 October 1968. Mean depth at first capture was 45 fathoms (82.3 m); mean depth at release was 71 fathoms (130 m). Fourteen lobsters were reported by specific location and seven by approximate location. Sex ratio at release was 138 females (62%) to 85 males; the ratio at return was 14 females (52%) to 13 males.

Mean time at large for all accountable (20) recoveries was 652 days (1.8 yr); greatest time at large for a located individual, a mature male at release, was 1,372 days (3.8 yr).

Mean distance traveled by those individuals with specific capture locations (14) was 37.4 miles (69.3 km); four individuals, three mature females and one mature male, surpassed the 50-mile (92.7-km) range as did six others which were reported from approximated canyon localities. Among this latter group, five of the six were larger, sexually mature individuals at release, thus confirming the apparent tendency of larger lobsters to migrate or disperse more so than smaller individuals. Maximum dispersion (132 miles = 245 km) was achieved by a mature male (937M) which had been at large 973 days (2.7 yr); this individual was recaptured in a coastal trap fishery on outer Cape Cod.

The single migrant of this group, a mature male (56M), moved easterly some 29 miles (53.7 km) over a period of

39 days and was recaptured at a depth of 100 fathoms (183 m); track direction and timing is consistent with hypothesized overwintering at and below the continental shelf margin. Return 357F, recaptured in October of the following year, is regarded as a migrant of the year 1969.

Composite Station 18 (See Figure 20 and Appendix Table 18)

Two hundred thirteen recaptures have been reported from a composite total of 1,350 releases some 7 miles (13.0 km) easterly of the head of Veatch Canyon on 30 April and 1 and 2 May 1969. Mean depth at first capture was 137 fathoms (251 m); mean depth at release was 71 fathoms (130 m). These subgroups, like several others, were released shoaler than capture depth to avoid the likelihood of immediate recapture by our own vessel or other commercial vessels trawling in the vicinity of initial capture. One hundred eleven of the recaptures were reported by specific location and 36 by approximate location. In Figure 20 the recoveries are grouped and plotted by 6-minute squares for reasons given earlier. Sex ratio at release was 582 females (43%) to 768 males. The ratio at return was 97 females (46%) to 116 males.

Mean time at large for all accountable (208) recoveries was 275 days (0.7 yr). Maximum time at large for a located individual (863F), a mature female at release, was 950 days (2.6 yr), during which time net displacement from release locality was only 7 miles (13.0 km).

Mean dispersion of the 111 recaptures with specific capture locations was 25.3 miles (46.9 km). Ten females and six males, the majority being mature at release, surpassed the 50-mile (92.7-km) range; among these 16, four (249F, 477F, 359M, 720M) ranged well beyond 100 miles (204 km).

Fifteen of the recoveries are defined migrants. The foremost example among these was 249F, a 90-mm female at release; this individual traveled a record 186 miles (345 km) in 71 days (2.6 miles/day = 4.8 km/day) and was recaptured in July in a trap fishery at 7 fathoms (12.8 m) depth on the north shore of Long Island. This extensive penetration into Long Island Sound might be interpreted as an initially directed shoalward vector toward Block Island Sound with unintended overrun into eastern Long Island Sound; thereafter, a southwesterly track would conceivably lead to the vicinity of recapture on the north shore of Long Island. Alternatively, once having entered the constricted eastern end of Long Island Sound, any near-southerly track would result in shoaling on the extensive north shore of Long Island and present the dilemma of choosing correctly between an easterly or westerly course for ultimate return to the open ocean. A westerly track alongshore would also, in this conjectural situation, effectively lead 249F to the point of recapture. This unforeseen situation raises the possibility that other lobsters of offshore origin may follow similar pathways and become entrapped in Long Island Sound by virtue of its confining geography.

The defined migrants within this group are listed below along with track bearing, ground speed, and depth change, and the positive values of depth change signify shoalward movement:

Return no.	Bearing	Ground speed		Depth change	
		mi/day	km/day	fathoms	meters
249F	302°	2.6	4.8	+68	+124
263F	348°	0.9	1.7	+50	+91
240F	036°	2.1	3.9	+36	+66
254F	069°	0.6	1.1	+42	+77
271F	278°	0.3	0.6	−20	−37
283F	073°	0.2	0.4	−20	−37
166F	060°	0.6	1.1	0	0
158F	058°	0.5	0.9	−5	−9
221F	081°	0.2	0.4	+10	+18
201M	072°	0.8	1.5	0	0
311M	006°	0.4	0.7	+45	+82
199M	067°	0.7	1.3	+5	+9
266M	296°	0.2	0.4	+15	+27
160M	066°	0.6	1.1	−12	−22
300M	072°	0.2	0.4	−20	−37

The initial bearing of 249F is measured to a point east of Montauk Point consistent with assumed straight-line penetration of eastern Long Island Sound; the subsequent track or tracks to point of recapture are highly conjectural as discussed above. Eight of the fifteen migrants moved shoalward, two remained at release depth, and five moved to deeper water. Among the five returning to deeper water, three were immature females.

Composite Station 19 (See Figure 21 and Appendix Table 19)

One hundred four recaptures have been reported from a single point release of 751 lobsters some 12 miles (22.2 km) southwesterly of Hydrographer Canyon on 4 May 1969. Depth at first capture was 150 fathoms (274 m); depth at release was 65 fathoms (119 m). Sixty-one recaptures were reported by specific location and 24 by approximate location. Sex ratio at release was 362 females (48%) to 389 males; the ratio at return was 57 females (55%) to 47 males.

Mean time at large for all accountable (96) recoveries was 286 days (0.8 yr); greatest time at large for a located individual (673F), a mature female at release, was 744 days (2.0 yr).

Mean distance traveled by individuals with specific capture locations (61) was 26.7 miles (49.5 km); seven individuals (294F, 610F, 246M, 317M, 480M, 570M, 577M) exceeded the 50-mile (92.7-km) range from release point. Six of these seven long-ranging individuals were sexually mature at release; the seventh (480M) was mature at recapture some 10 mo from release.

Maximum dispersion (125 miles = 232 km) was achieved by a mature male (317M) which moved northeasterly onto Georges Shoals at an apparent ground speed of 1.4 miles (2.6 km) per day. Two others (294F, 570M) also exceeded the 100-mile (185-km) range; these three cases of wide dispersion from release point are good examples of the contrasting distinction between defined migrants (317M and 294F) and the defined indeterminate (570M): the former show ground speeds in excess of 1 mile (1.85 km) per day along hypothetical track lines that are probably realistic approximations of actual tracks made good; the latter (570M) was recaptured 14 mo after release and shows a net displacement of 115 miles (213 km). In this situation, the track is simply a straight-line resolution of some unknown number of movements over long term which have resulted in a major westerly displacement; the timing and directionality of the component steps cannot be deduced or inferred from the available information.

The defined migrants (13) within this group are listed below with ground speed and depth change:

Return no.	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
255F	0.6	1.1	+45	+82
294F	1.1	2.0	+47	+86
654F	1.1	2.0	+32	+59
146F	0.4	0.7	0	0
152F	0.4	0.7	−7	−13
184F	0.4	0.7	+10	+18
191F	0.3	0.6	+15	+27
282F	0.1	0.2	−25	−46
246M	0.8	1.5	+48	+88
290M	0.5	0.9	−25	−46
317M	1.4	2.6	+38	+70
190M	0.3	0.6	+15	+27
194M	0.4	0.7	+10	+18

Composite Station 20 (See Figure 22 and Appendix Table 20)

Forty-four recaptures have been reported from a composite total of 387 releases made 25 miles (46.3 km) southwest of Corsair Canyon over the 3-day period, 7, 8, and 9 May 1969. Mean depth at first capture was 173 fathoms (316 m) with range 160-180 fathoms (293-329 m); depth at release for all releases was 50 fathoms (91.4 m). Thirty-seven recaptures were reported by specific location and one by approximate location. Sex ratio at release was 274 (71%) females to 113 males; the ratio at return was 29 (66%) females to 15 males.

Mean time at large for accountable (44) recoveries was 199 days (0.5 yr); greatest time at large for a located individual (897M), a mature male at release, was 1,075 days (2.9 yr) with recapture 27 miles (50.0 km) from release point.

Mean distance traveled by individuals with specific capture locations (37) was 30.4 miles (56.3 km); four individuals (306F, 315F, 578F, 697F), all sexually mature females, equalled or exceeded the 50-mile (92.7-km) range from point of release. Maximum dispersion (143 miles = 265 km) was attained by 697F which was recaptured near Veatch Canyon 761 days (2.1 yr) following release. This group of recoveries includes the second largest number (21) and percentage (56) of definable migrants, 21 of 37. Collectively, the migrants are characterized by relatively large size, a high proportion (76%) of females, and, among the females, a high proportion (44%) with external eggs at release.

The defined migrants (21) within this group are listed below with track bearing, ground speed, and depth change:

Return no.	Bearing	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
148F	056°	1.0	1.9	−85	−155
161F	227°	0.8	1.5	−40	−73
244F	329°	0.5	0.9	+16	+29
252F	329°	0.5	0.9	+16	+29
259F	327°	0.7	1.3	+23	+42
276F	337°	0.5	0.9	+18	+33
277F	337°	0.5	0.9	+18	+33
306F	323°	0.5	0.9	+22	+40
314F	314°	0.6	1.1	+23	+42
315F	315°	0.6	1.1	+23	+42
171F	036°	0.3	0.6	−45	−82
198F	222°	0.4	0.7	−35	−64
209F	079°	0.2	0.4	−42	−77
228F	225°	0.2	0.4	−30	−55
239F	079°	0.2	0.4	−32	−59
247F	009°	0.3	0.6	+11	+20
149M	056°	1.0	1.9	−85	−155
150M	043°	1.0	1.9	−85	−155
200M	334°	0.8	1.5	+13	−24
285M	325°	0.5	0.9	+20	−37
210M	079°	0.2	0.4	−32	−59

It will be noted from the preceding table and Figure 22 that 10 of the 11 migrants showing shoalward displacement were recovered within a 33° arc relative to release point; the significance of this tight grouping is evident only when the recovery positions are plotted on a detailed bathymetric chart of the area encompassed from which it can be seen that the recapture locations are coincident with several areas that are heavily fished in summer months by trawlers fishing primarily for yellowtail flounders. The rugged topography of Georges Bank shoalward of 30 fathoms (54.9 m), coupled with strong tidal currents, greatly limits trawler activity and hence the incidental catch of shoaling lobsters to those areas that are topographically compatible with otter trawl fishing. The relatively large number of tagged lobsters recaptured on this shoaler part of Georges Bank (see also Fig. 24 and related discussion) indicates that this upper reach of the Bank as a whole supports a major summertime concentration of lobsters originating from the continental margin and slope from Veatch Canyon eastward.

Composite Station 21 (See Figure 23 and and Appendix Table 21)

Twenty-three recaptures have been reported from a single point release of 166 lobsters near the head of Lydonia Canyon on 6 June 1969. Depth at first capture was 70 fathoms (128 m); depth at release was 57 fathoms (104 m). Fifteen recaptures were reported by specific locations and six by approximate location. Sex ratio at release was 82 females (49%) to 84 males; the ratio at return was 7 females (30%) to 16 males.

Mean time at large for all accountable (19) recoveries was 264 days (0.7 yr); greatest time at large for a located individual (851M), a mature male at release, was 885 days (2.4 yr).

Mean distance traveled by individuals with specific capture locations (15) was 30.1 miles (55.8 km); four individuals (186F, 262F, 399F, 352M), all sexually mature at release, exceeded the 50-mile (92.7-km) range from release point.

Maximum dispersion was attained by 399F which moved a net distance of 82 miles (152 km) easterly over a period of 167 days (0.4 yr).

The defined migrants (4) within this group of recaptures are listed below with track bearing, ground speed, and depth change:

Return no.	Bearing	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
262F	032°	1.7	3.2	+24	+44
352M	304°	0.6	1.1	+2	+4
230M	117°	0.5	0.9	−23	−42
231M	117°	0.5	0.9	−23	−42

Return 262F (44 days at large) approaches the idealized view of seasonal shoalward migration, but 352M, 230M, and 231M do not. In view of their relatively short term at large (22 days) it is possible that these last three had simply reoriented toward the depth-temperature stratum prevailing at first capture.

Recoveries 185F, 186F, and 399F fall outside the migrant classification, but represent significant dispersions with respect to time at large or distance. Both 185F and 186F were at large less than 10 days, but made seemingly directed tracks (without depth change) of 40 miles (74.1 km) and 52 miles (96.4 km), respectively, at calculated ground speeds in excess of 5 miles (9.3 km) per day. Return 399F (167 days at large) was captured at a point 82 miles (152 km) westerly and 17 fathoms (31.1 m) shoaler than point of release; this dispersion is open to interpretation, but may represent the outbound limit of a shoalward migration or simply a point on an inbound return from an even shoaler location.

Composite Station 22 (See Figure 24 and Appendix Table 22)

Forty-six recaptures have been reported from a composite total of 422 releases some 20 miles (37.1 km) southwest of the head of Corsair Canyon on 10 and 11 June 1969. Mean depth at first capture was 87 fathoms (159 m); mean depth at release was 51 fathoms (93.3 m). Thirty-nine lobsters were reported by specific location and one by approximate location. Sex ratio at release was 280 females (66%) to 142 males; the ratio at return was 28 females (61%) to 18 males.

Mean time at large for all accountable (43) recoveries was 157 days (0.4 yr); greatest time at large for a located individual (898M), a mature male at release, was 1,034 days (2.8 yr) with recapture 11 miles (20.4 km) from release point. This individual showed a 39% increase in carapace length at recapture which suggests that at least two molts occurred during its time at large.

Mean distance traveled by individuals with specific capture locations (39) was 44 miles (81.5 km); five individuals (237F, 575F, 770F, 303M, 747M) surpassed the 50-mile (92.7-km) range from point of release by a considerable margin (range 87-164 miles = 161-304 km). Maximum movement was attained by 747M (see Fig. 24) which was recaptured 865 days (2.4 yr) following release; runner-up in this category was 575F, a large egg-bearing female at release, which was taken in a coastal trap fishery at Truro Beach, Mass., 431 days (1.2 yr) following release.

This group of recoveries includes the largest number (28) and percentage (71) of definable migrants with 28 of 39 located recoveries meeting the "migrant" criteria defined previously. The migrants here, as at station 20, are characterized by large mean size, a high proportion (61%) of females, and, among the females, a high proportion (59%) with external eggs at release.

Bearing, ground speed, and depth change are given below:

Return no.	Bearing	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
236F	316°	1.7	3.2	+17	+31
237F	240°	4.4	8.2	−8	−15
238F	337°	1.5	2.8	+18	+33
251F	338°	1.0	1.9	+18	+33
260F	331°	1.0	1.9	+25	+46
284F	322°	0.5	0.9	+17	+31
287F	328°	0.6	1.1	+21	+38
288F	332°	0.6	1.1	+22	+40
293F	329°	0.6	1.1	+14	+26
307F	302°	0.7	1.3	+22	+40
308F	302°	0.7	1.3	+22	+40
309F	302°	0.7	1.3	+22	+40
316F	307°	0.9	1.7	+25	+46
336F	300°	0.5	0.9	+25	+46
337F	300°	0.5	0.9	+25	+46
339F	310°	0.5	0.9	+20	+37
208F	117°	0.8	1.5	−40	−73
222M	322°	1.0	1.9	+14	+26
242M	333°	1.4	2.6	+12	+22
243M	330°	1.4	2.6	+20	+37
248M	325°	1.3	2.4	+24	+44
258M	317°	0.9	1.7	+23	+42
261M	331°	0.9	1.7	+19	+35
278M	317°	0.7	1.3	+18	+33
303M	243°	1.6	3.0	−23	−42
310M	341°	0.6	1.1	+20	+37
341M	317°	0.4	0.7	+18	+33
342M	317°	0.4	0.7	+18	+33

All but three (208F, 237F, 303M) of the migrants ranged significantly shoalward from point of release and were recaptured within 89 days from date of release. Migrant 208F moved quickly toward deeper water approximating depth at first capture; migrant 237F, a large egg-bearing female, moved rapidly some 87 miles (161 km) in 20 days to be recaptured near the head of Oceanographer Canyon in only slightly deeper water; migrant 303M, a large male, moved 123 miles (228 km) in 76 days to be recaptured on the east flank of Hydrographer Canyon in significantly deeper water. These movements do not conform to a working hypothesis of springtime shoalward migration but they illustrate the kind of exceptions that inevitably arise in attempted classification of the movements of tagged animals over a short term; the long distance traveled by 237F and 303M, both at high rates of speed, tend to infer directionality on their movements that are inconsistent with our hypothesis; the close agreement of the track bearings might well be coincidence, but a rational conclusion, nevertheless, is that the tracks are similar results of disoriented attempts to return to original release depth.

The exceptions noted above notwithstanding, the balance (25) of these migrants effected movements that were highly consistent in directionality, time at large, and distance. Inspection of Appendix Table 22 shows that all were recaptured within the range 20-89 days at net distances from point of release ranging from 22 to 48 miles (40.8-89.0 km); bearings of the net tracks are confined to the narrow range 300°-341° with effective shoaling ranging from 17 to 25 fathoms (31.1-45.7 m). This particular group of defined migrants amply supports our prevailing hypothesis and serves to illustrate better than any other the concept of the outbound (shoalward) phase of seasonal migration.

Composite Station 23 (See Figure 25 and Appendix Table 23)

Thirty-four recaptures have been reported from a composite total of 301 releases near the east flank of Welker Canyon on 19 and 20 June 1969. Mean depth at first capture was 61 fathoms (112 m); mean depth at release was 82 fathoms (150 m). Twenty-eight lobsters were reported by specific location and two by approximate location. Sex ratio at release was 139 females (46%) to 162 males; the ratio at return was 20 females (59%) to 14 males.

Mean time at large for all accountable (32) recoveries was 249 days (0.7 yr); greatest time at large for a located individual (848F), an egg-bearing female at release, was 506 days (1.4 yr) with recapture 16 miles (29.7 km) from original release point.

Mean distance traveled by individuals with specific capture locations (28) was 35 miles (64.9 km); eight individuals (576F, 728F, 771F, 562M, 564M, 767M, 769M, 797M) surpassed the 50-mile (92.7-km) range from point of release with two of these (728F, 797M) exceeding 100 miles (185 km). Maximum dispersion of 126 miles (234 km) westerly was accomplished by 728F while at large 348 days (0.95 yr); this individual bore ripe external eggs at recapture which, coupled with zero growth over the period at large, implies that egg deposition occurred shortly after release.

Only four of the recaptures qualify as migrants; all were recaptured in significantly shoaler water with at least three of the four effecting large-scale movements over relatively short term. Calculated bearing, ground speed, and depth change of these migrants are given below:

Return no.	Bearing	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
576F	313°	1.1	2.0	+59	+108
584F	344°	0.5	0.9	+51	+93
562M	285°	5.0	9.3	+52	+95
564M	282°	5.5	10.2	+50	+91

The net tracks exhibited by 576F and 548F approach the idealized view of directed shoalward movements; the tracks of 562M and 564M are good, in the comparative sense, but less than ideal in terms of the best vector toward shoaler water. These two migrants rank first and third for calculated ground speed among the 117 defined migrants.

Probable migrations are evident in the respective locations of at least four other individuals (767F, 769M, 797M, 771F); each of these lobsters was recaptured approximately 1 yr after release at depths (20-35 fathoms = 36.6-64.0 m) consistent with hypothesized summertime distribution. It should be noted that here, as elsewhere, perambulations beyond one season cannot be approximated by a straight-line track; this simple convention is probably a valid estimator in cases of defined migrants, but where movements are summed over two or more migration cycles, the track-line can be nothing more than a measure of temporal displacement from point of release.

Composite Station 24 (See Figure 26 and Appendix Table 24)

Twenty-two recaptures have been reported from a composite release of 173 lobsters 10 miles (18.5 km) west of Oceanographer Canyon on 19 and 22 June 1970. Mean depth at first capture was 59 fathoms (108 m); mean depth at release was 57 fathoms (104 m). Fifteen lobsters were reported by specific location and four by approximate location. Three recaptures were reported without location information of any kind. Sex ratio at release was 72 females (42%) to 101 males; the ratio at return was 14 females (64%) to 9 males.

Mean time at large for all accountable (22) recoveries was 290 days (0.8 yr); greatest time at large for a located individual (883F), a mature female at release, was 512 days (1.4 yr) with recapture 18 miles (33.4 km) from release point.

Mean distance traveled by individuals with specific capture locations (15) was 24 miles (44.5 km); two individuals (569F, 648M) surpassed the 50-mile (92.7-km) radius of dispersion. Recapture 569F, the only qualified migrant among the returns, moved 74 miles (137 km) southwesterly in 16 days (4.6 miles/day = 8.5 km/day) to equivalent depth near Veatch Canyon; recapture 648M was taken 136 miles (252 km) westerly near Block Canyon following 207 days at large.

Composite Station 25 (See Figure 27 and Appendix Table 25)

Ten recaptures have been reported from a composite release of 60 trap-caught lobsters near Block Canyon on 6 and 7 January 1971. Twenty-four were captured, tagged, and released at 115 fathoms (210 m); 36 others were taken, tagged, and released at 212 fathoms (388 m). All recaptures were reported by specific location. Sex ratio at release was 30 females (50%) to 30 males; the ratio at recapture was 6 females (60%) to 4 males.

Mean time at large for the 10 recoveries was 285 days (0.8 yr); greatest time at large for a given individual (920M), a mature male at release, was 530 days (1.5 yr) with subsequent recapture 4 miles (7.4 km) from release point.

Mean distance ranged by the 10 recaptures was 15 miles (27.8 km); maximum dispersion of 54 miles (100 km) was attained by 798F while at large 163 days (0.4 yr); all other dispersions were 29 miles (53.7 km) or less with two (735F, 734M) recaptured at original release locations following some 6 mo at large.

None of the recaptures meet the migrant criteria as defined.

Composite Station 26 (See Appendix Table 26)

Only a single recapture has been reported from a composite total of 54 releases (trap-caught) southwest of Hudson Canyon on 25 January and 21 February 1971. The initial group of 50 lobsters was caught and released at 225 fathoms (412 m); the second group of four was caught and released at 300 fathoms (549 m). Sex ratio at release was 17 females (31%) to 37 males.

The single recovery (647M), a mature male at release, was at large 112 days (0.3 yr) prior to recapture at an unspecified location.

Composite Station 27 (See Figure 28 and Appendix Table 27)

Eleven recaptures have been reported from a composite release of 194 trap-caught lobsters 15 miles (27.8 km) south of Baltimore Canyon on 7, 8, 10, and 11 February 1971. Forty-seven were captured and released at 185 fathoms (338 m); 24 were captured and released at 292 fathoms (534 m); 123 were captured and released at 150 fathoms (274 m). All of the recaptures were reported by specific location. The sex ratio at release was 99 females (51%) to 95 males; the ratio at return was 6 females (54%) to 5 males.

Mean time at large for all recoveries was 452 days (1.3 yr); greatest time at large was 620 days (1.7 yr) with net displacement of only 4 miles (7.4 km).

Mean distance traveled by the 11 recaptures was 24 miles (44.5 km); two individuals (740F, 917F) exceeded the 50-mile (92.7-km) range. Maximum dispersion was attained by 917F which was taken in a coastal trap fishery near Cape May, N.J., some 71 miles (132 km) from release location.

None of the recaptures meet migrant criteria.

Composite Station 28 (See Appendix Table 28)

Three recaptures have been reported from a single point release of 29 trap-caught lobsters 25 miles (46.3 km) southwest of Hudson Canyon on 22 February 1971. Capture and release depth was 250 fathoms (457 m); sex ratio at release was 14 females (48%) to 15 males.

Mean time at large for the three recoveries was 184 days (0.5 yr); greatest time at large was 479 days (1.3 yr) with only 9 miles (16.7 km) displacement from release locality.

Mean distance ranged by the three recoveries was only 7.6 miles (14.1 km), the range being 7-9 miles (13.0-16.7 km).

None of these recaptures meet the migrant criteria as defined.

Composite Station 29 (See Figure 29 and Appendix Table 29)

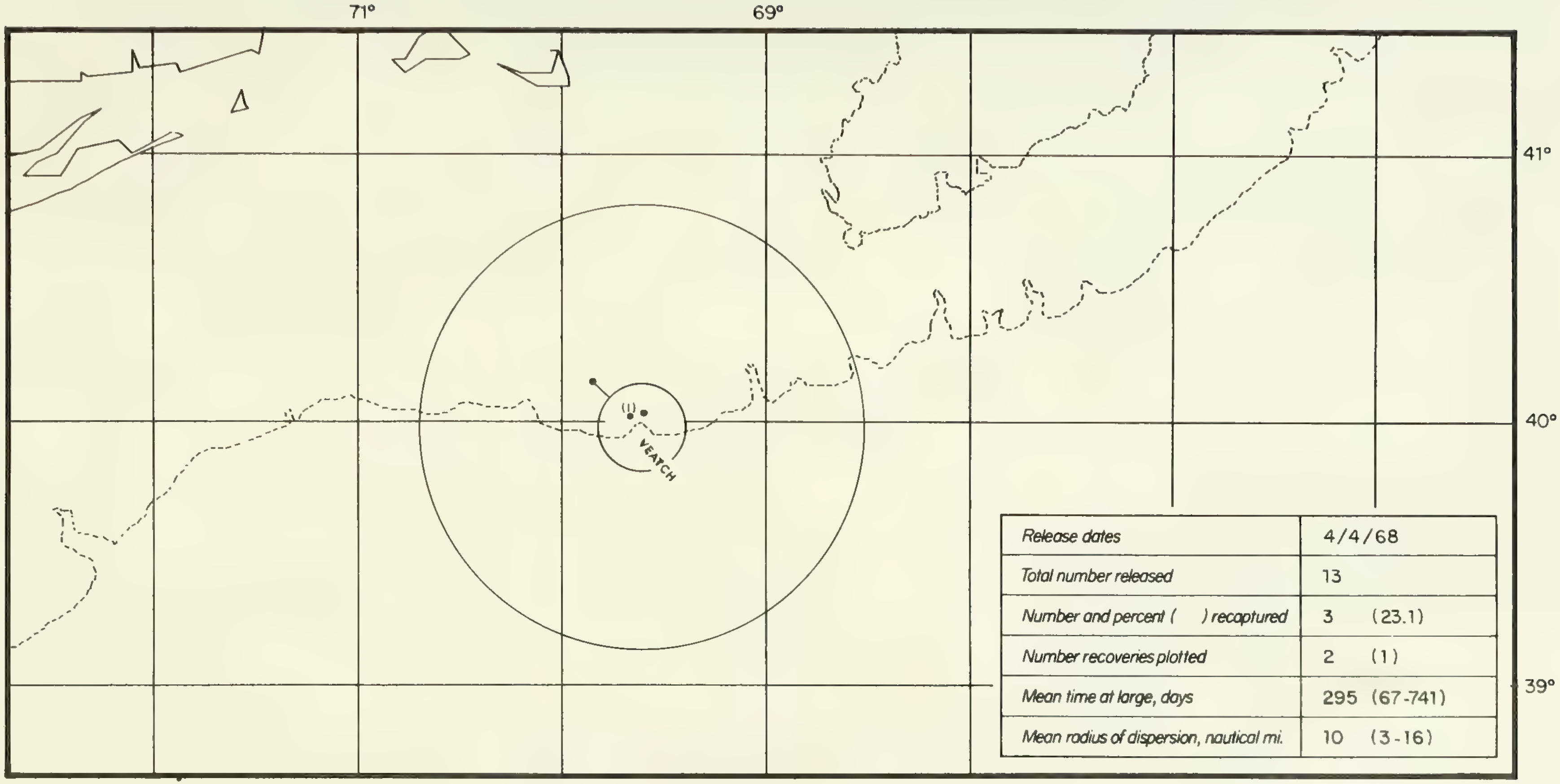
One hundred fifty-five recaptures have been reported from a composite release of 805 trap-caught lobsters at Veatch Canyon on 9 and 10 May 1971.

This series of releases was made by one of us (Richard A. Cooper) while participating as scientific observer during commercial trap-fishing operations of the FV *Wily Fox* owned and operated by the Prelude Lobster Corporation of Westport, Mass. The lobsters that were tagged were, for the most part, either sublegal by size, or egg-bearing females, and would normally have been discarded as the traps were hauled and emptied. This tagging strategy was not used on any other cruise. All other lobsters were trawl-caught or trapped (composite stations 25, 26, 27, 28) by research vessels previously named; among these trap-caught lobsters all that were viable at capture were tagged and released with the exception of those which were dead or moribund (<1%) after the posttagging holding period.

One hundred fifty of the tagged lobsters were captured and released at 60 fathoms (110 m); the second group of 655 was captured and released at 55 fathoms (101 m). Sixty-three of the recaptures were reported by specific location, 83 by approximate location, and 9 without location information of any kind. Sex ratio at release was 621 females (77%) to 184 males; the ratio of recaptures was 105 females (68%) to 50 males.

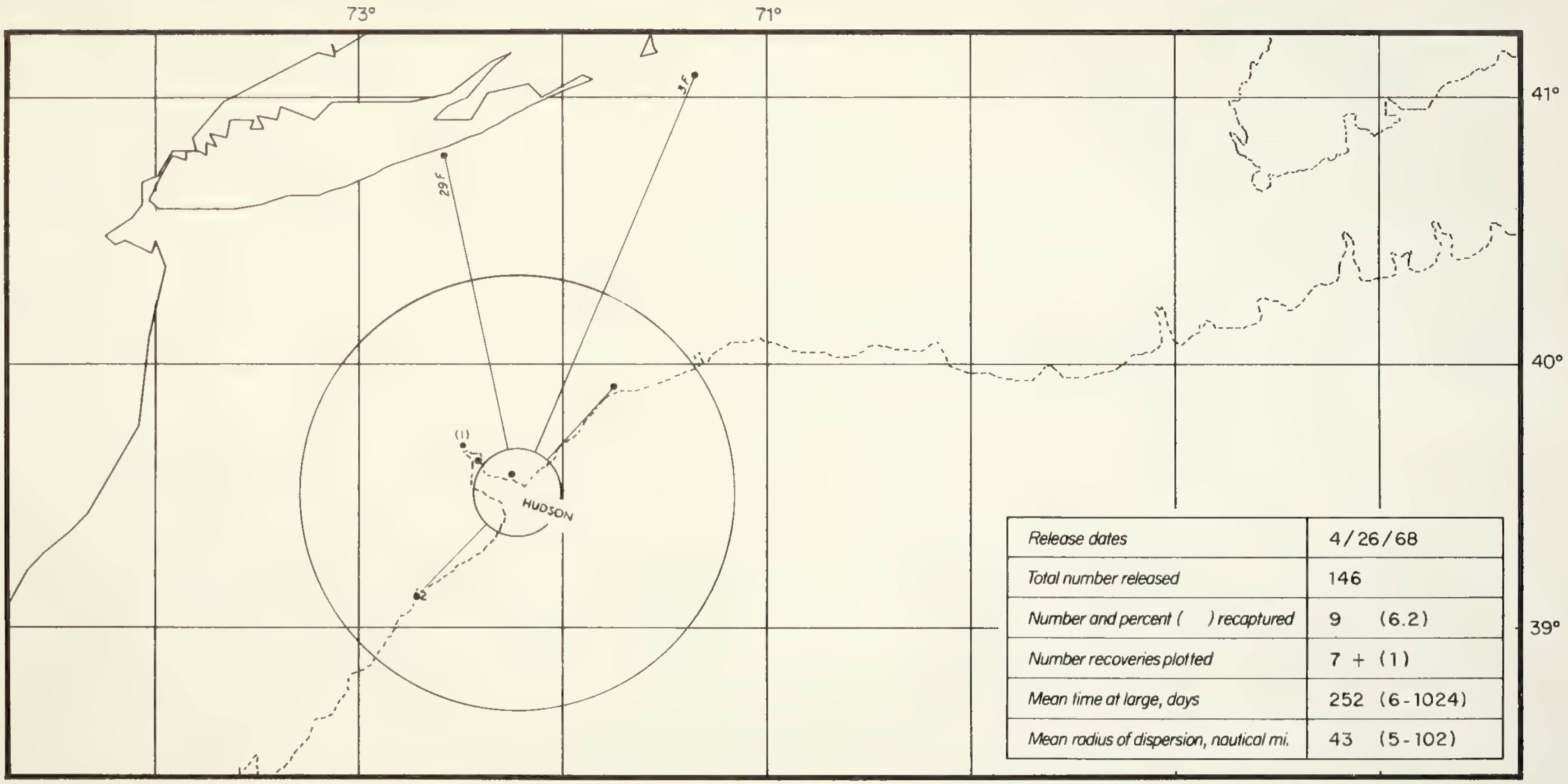
Mean time at large for all accountable (154) recoveries was 183 days (0.5 yr); greatest time at large for a located individual (953F), an immature female at release, was 492 days (1.3 yr) with recapture 18 miles (33.4 km) from release point.

Mean distance traveled by individuals with specific capture locations (63) was 15 miles (27.8 km); five lobsters (721F, 738F, 926F, 758M, 895M) surpassed the 50-mile (92.7-km) range with each of the two males exceeding 100 miles (185 km). Maximum dispersion of 111 miles (206 km) northerly to Cuttyhunk Island was attained by 758M while at large 108 days; this migration (by prior definition) into the coastal trap fishery is a further example of the evident, but unmeasured, annual recruitment to coastal stocks by lobsters of offshore origin. The net dispersion of 895M over 221 days to a point 102 miles (189 km) westerly could conceivably have been the summation of a shoalward migration such as



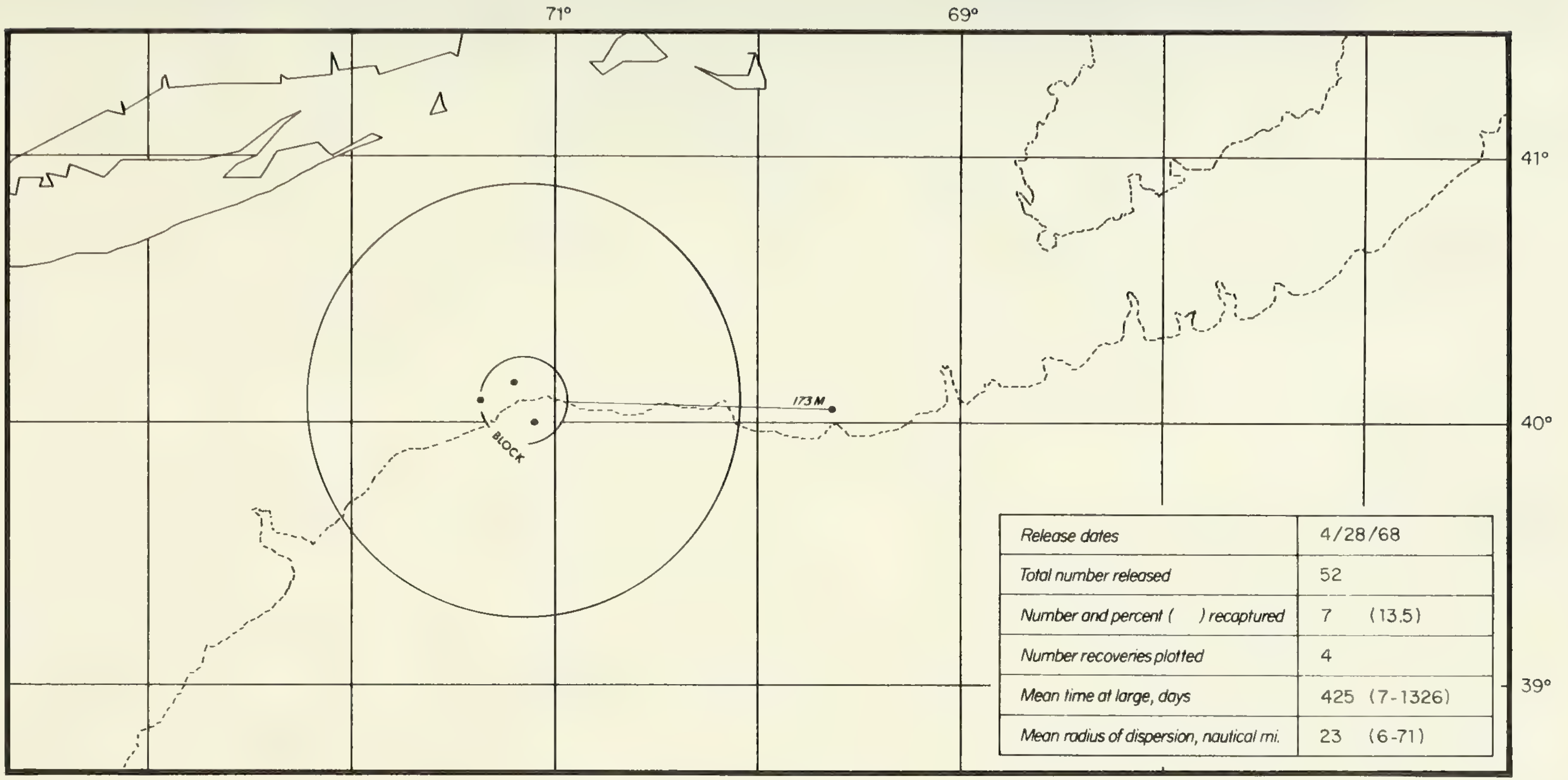
Release dates	4/4/68
Total number released	13
Number and percent ( ) recaptured	3 (23.1)
Number recoveries plotted	2 (1)
Mean time at large, days	295 (67-741)
Mean radius of dispersion, nautical mi.	10 (3-16)

Figure 5.—Recoveries from composite station 2.



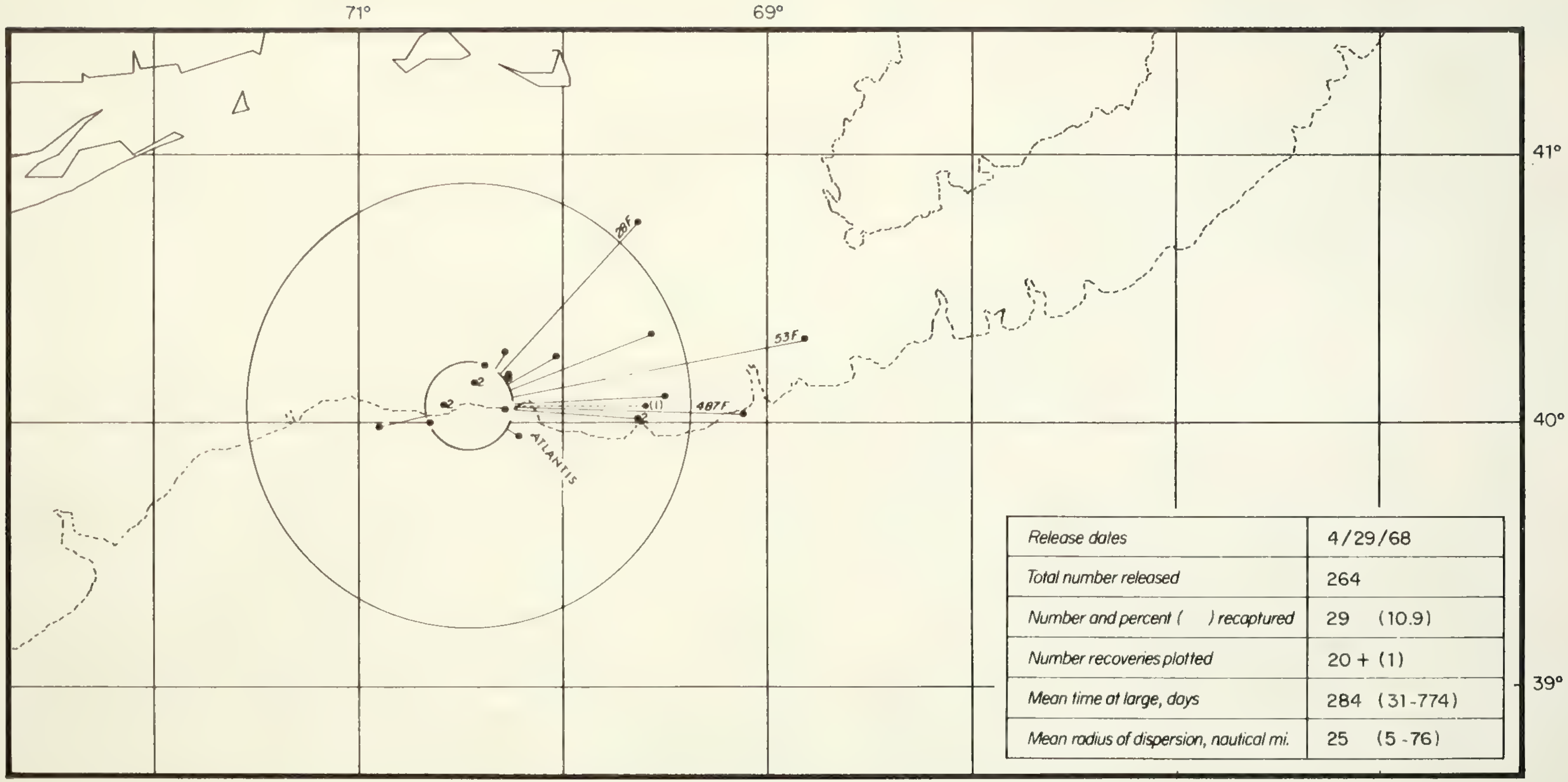
Release dates	4/26/68
Total number released	146
Number and percent ( ) recaptured	9 (6.2)
Number recoveries plotted	7 + (1)
Mean time at large, days	252 (6-1024)
Mean radius of dispersion, nautical mi.	43 (5-102)

Figure 6.—Recoveries from composite station 3.



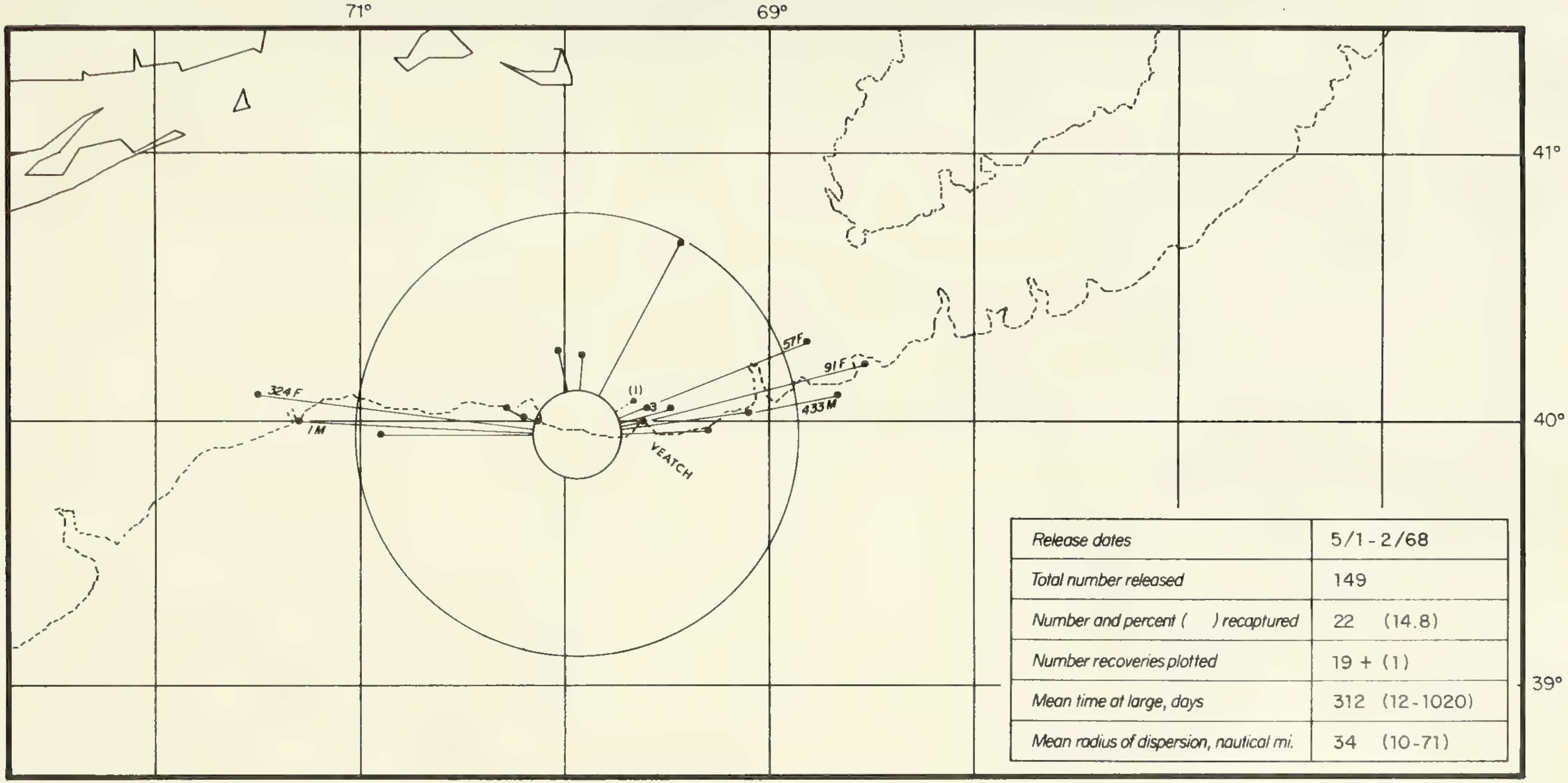
Release dates	4/28/68
Total number released	52
Number and percent ( ) recaptured	7 (13.5)
Number recoveries plotted	4
Mean time at large, days	425 (7-1326)
Mean radius of dispersion, nautical mi.	23 (6-71)

Figure 7.—Recoveries from composite station 4.



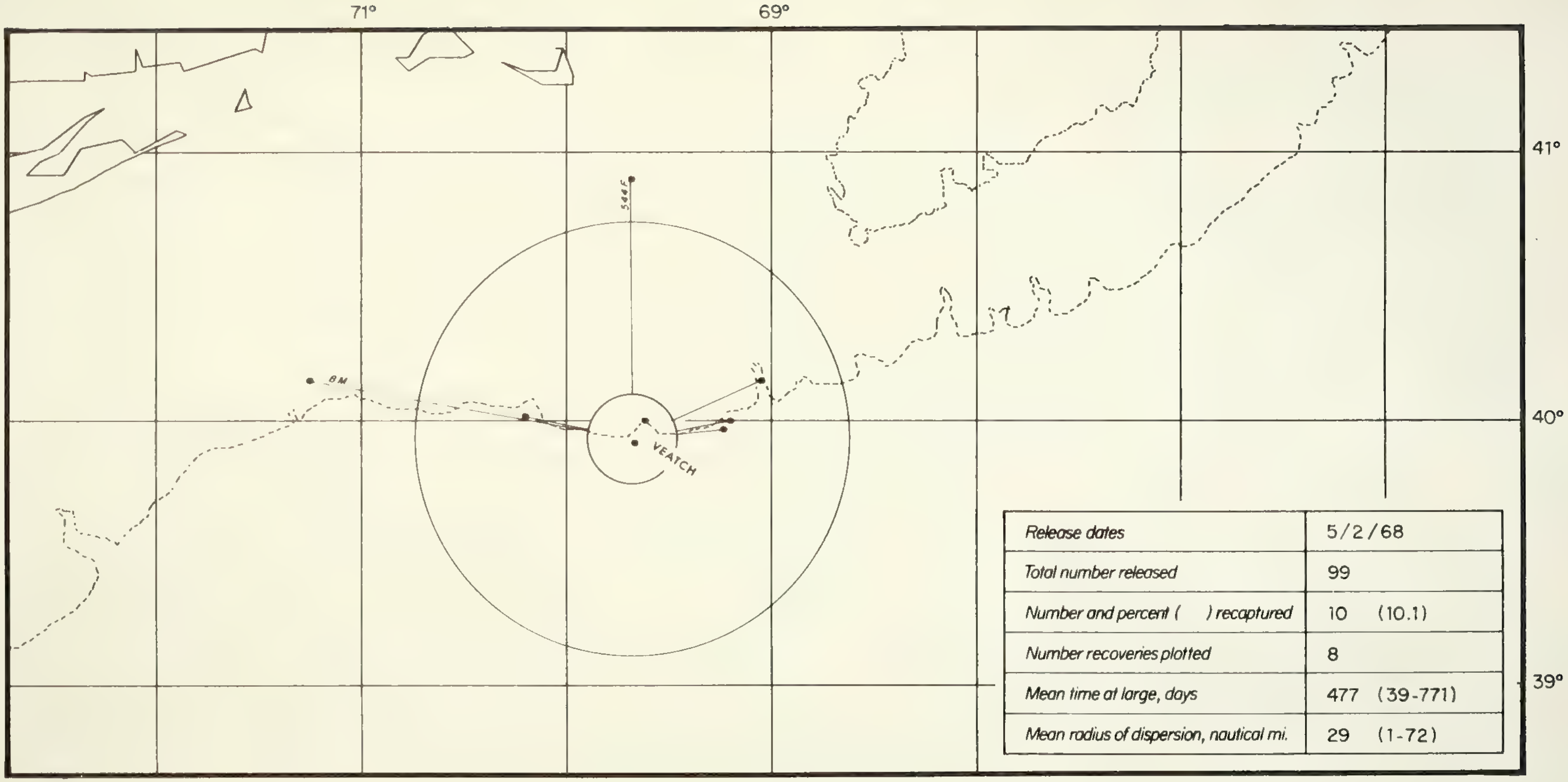
Release dates	4/29/68
Total number released	264
Number and percent ( ) recaptured	29 (10.9)
Number recoveries plotted	20 + (1)
Mean time at large, days	284 (31-774)
Mean radius of dispersion, nautical mi.	25 (5-76)

Figure 8.—Recoveries from composite station 5.



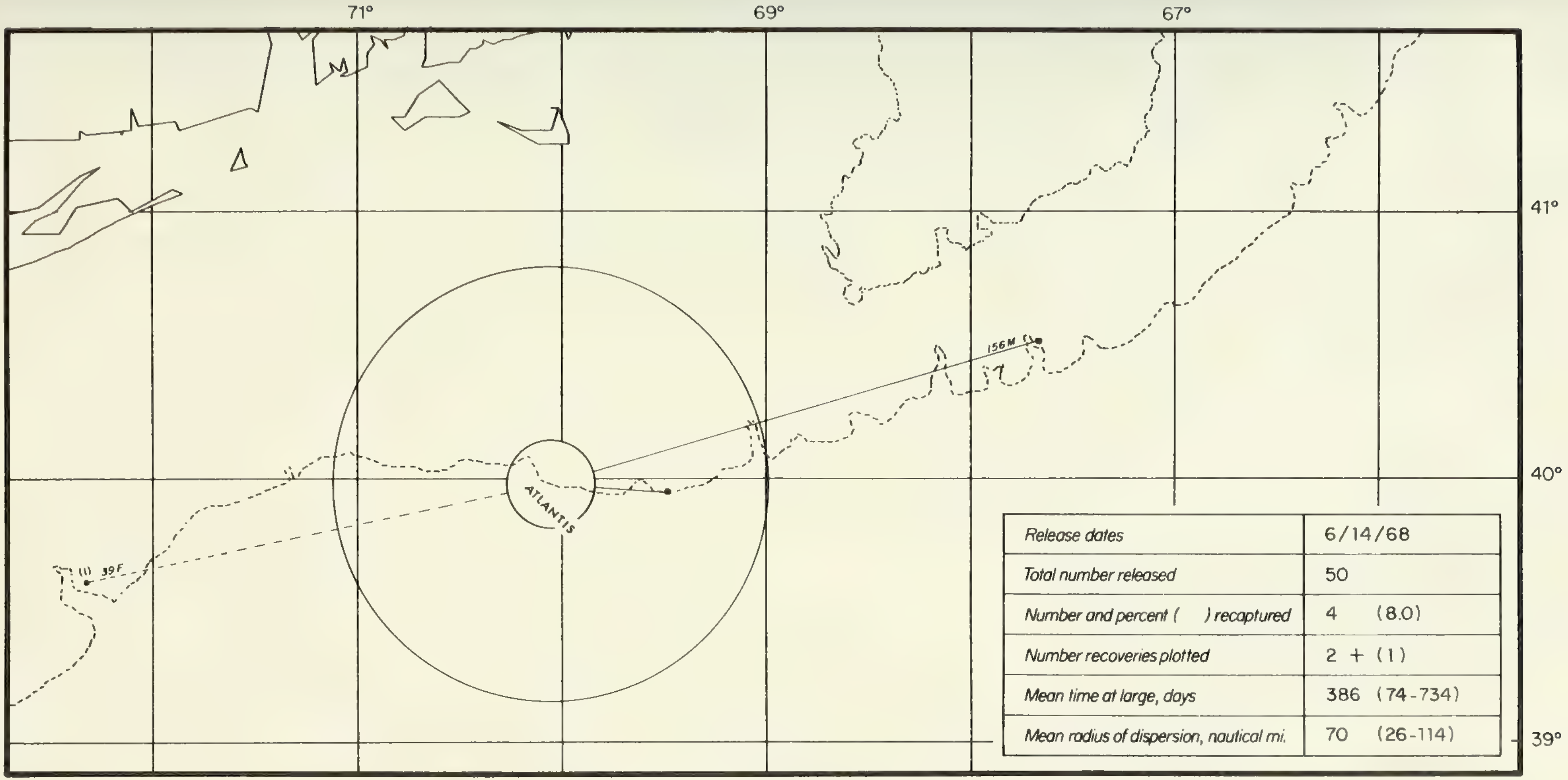
Release dates	5/1 - 2/68
Total number released	149
Number and percent ( ) recaptured	22 (14.8)
Number recoveries plotted	19 + (1)
Mean time at large, days	312 (12-1020)
Mean radius of dispersion, nautical mi.	34 (10-71)

Figure 9.—Recoveries from composite station 6.



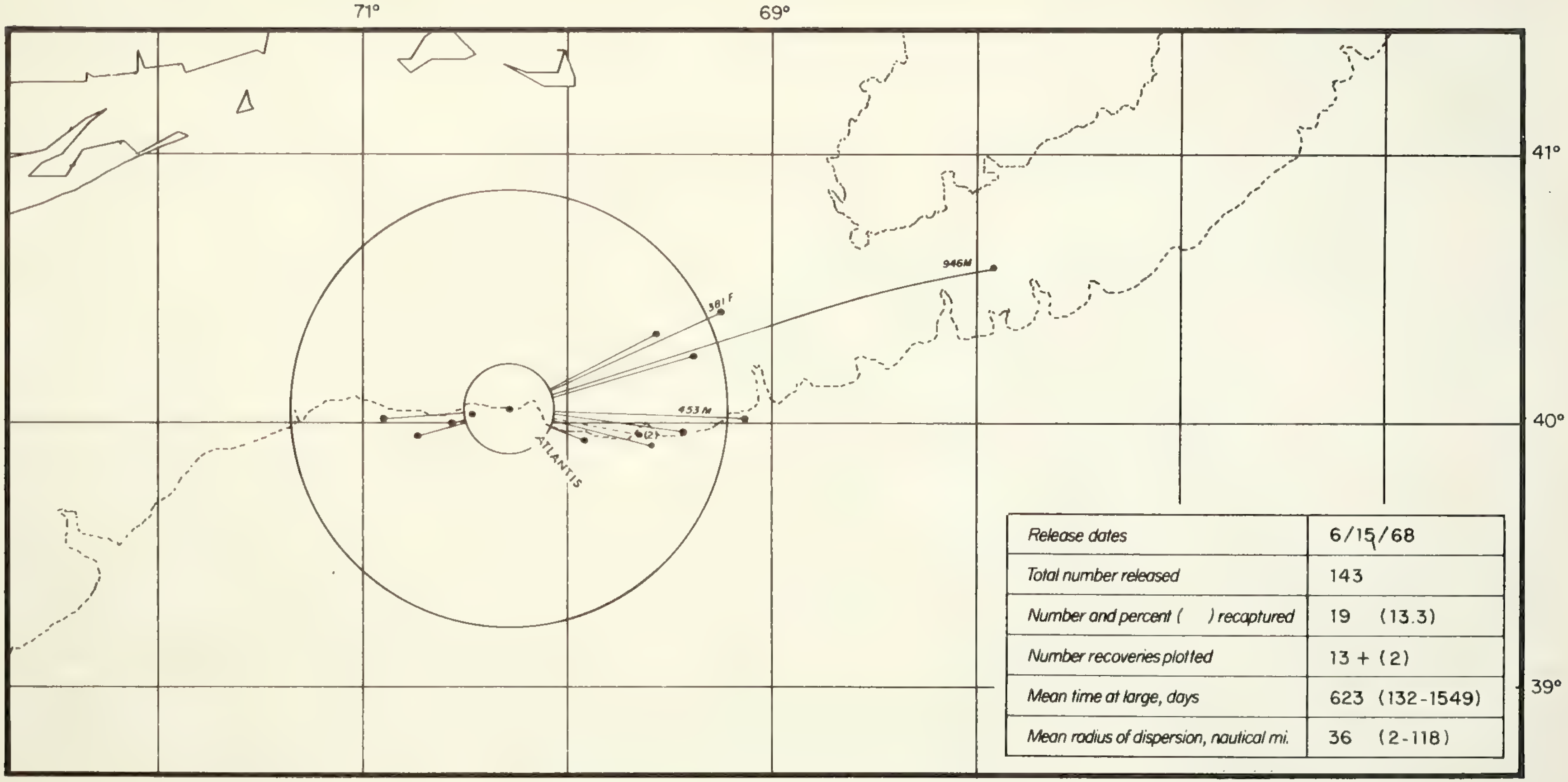
Release dates	5/2/68
Total number released	99
Number and percent ( ) recaptured	10 (10.1)
Number recoveries plotted	8
Mean time at large, days	477 (39-771)
Mean radius of dispersion, nautical mi.	29 (1-72)

Figure 10.—Recoveries from composite station 7.



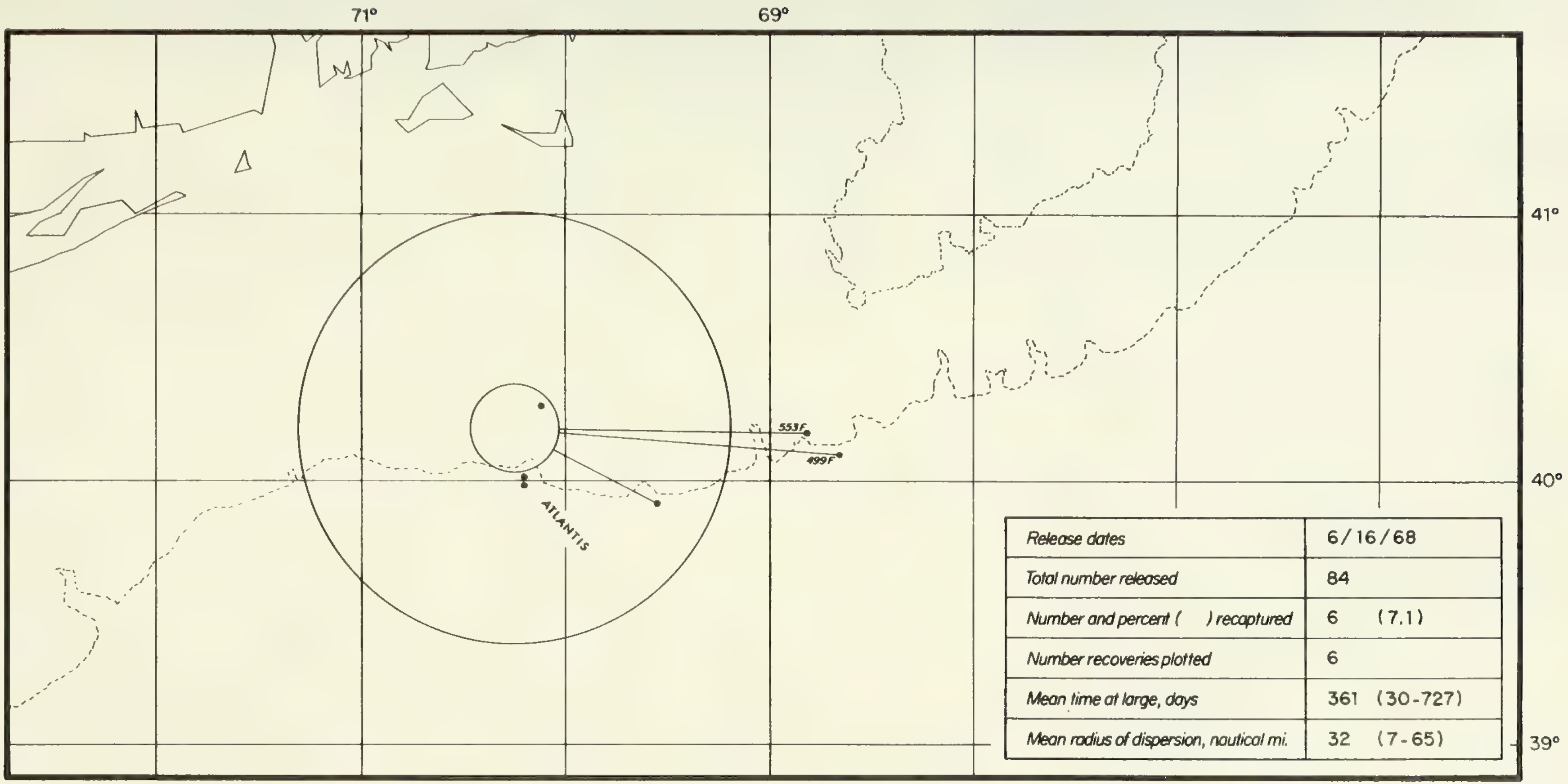
Release dates	6/14/68
Total number released	50
Number and percent ( ) recaptured	4 (8.0)
Number recoveries plotted	2 + (1)
Mean time at large, days	386 (74-734)
Mean radius of dispersion, nautical mi.	70 (26-114)

Figure 11.—Recoveries from composite station 8.



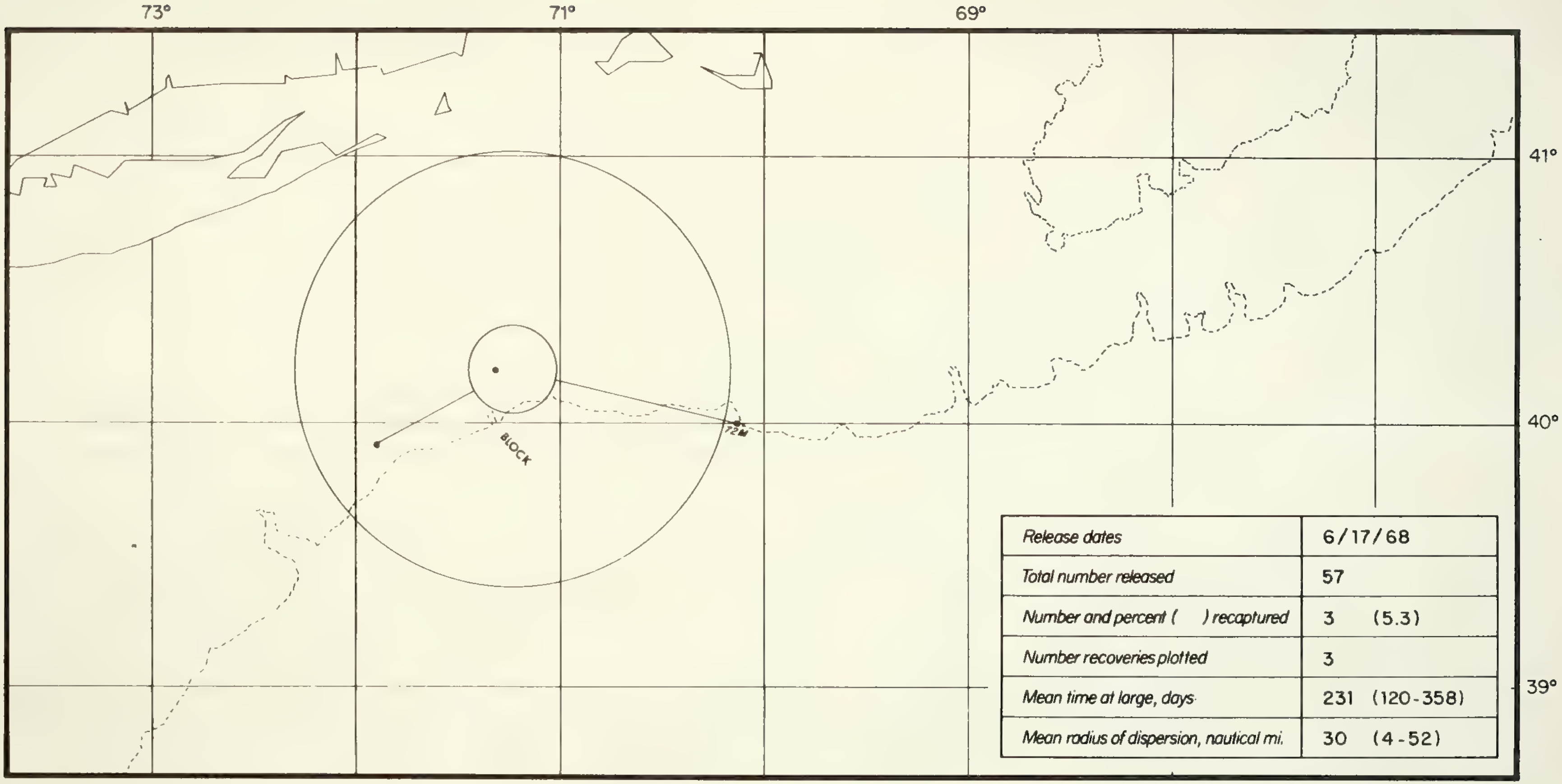
Release dates	6/15/68
Total number released	143
Number and percent ( ) recaptured	19 (13.3)
Number recoveries plotted	13 + (2)
Mean time at large, days	623 (132-1549)
Mean radius of dispersion, nautical mi.	36 (2-118)

Figure 12.—Recoveries from composite station 9.



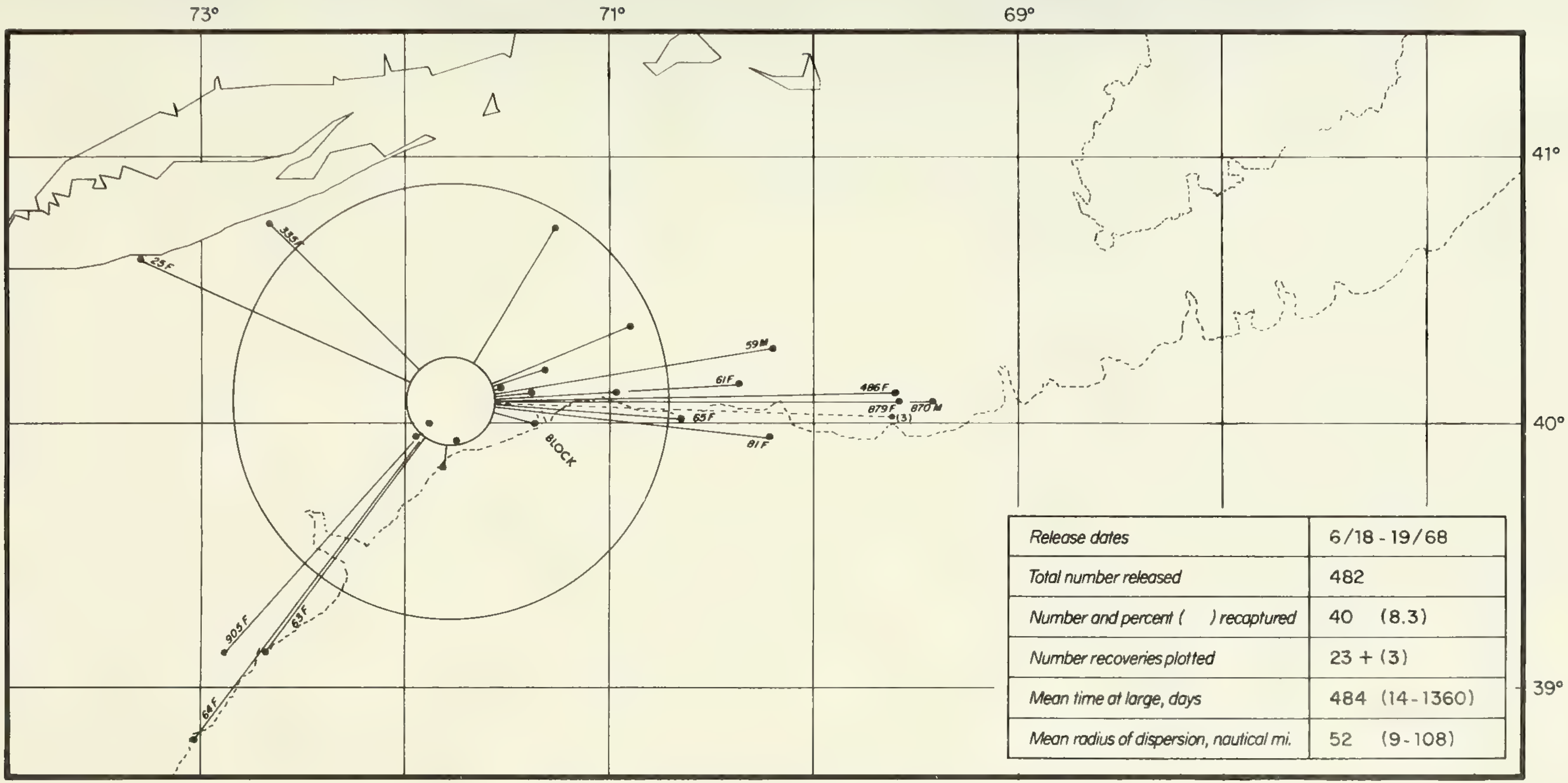
Release dates	6/16/68
Total number released	84
Number and percent ( ) recaptured	6 (7.1)
Number recoveries plotted	6
Mean time at large, days	361 (30-727)
Mean radius of dispersion, nautical mi.	32 (7-65)

Figure 13.—Recoveries from composite station 11.



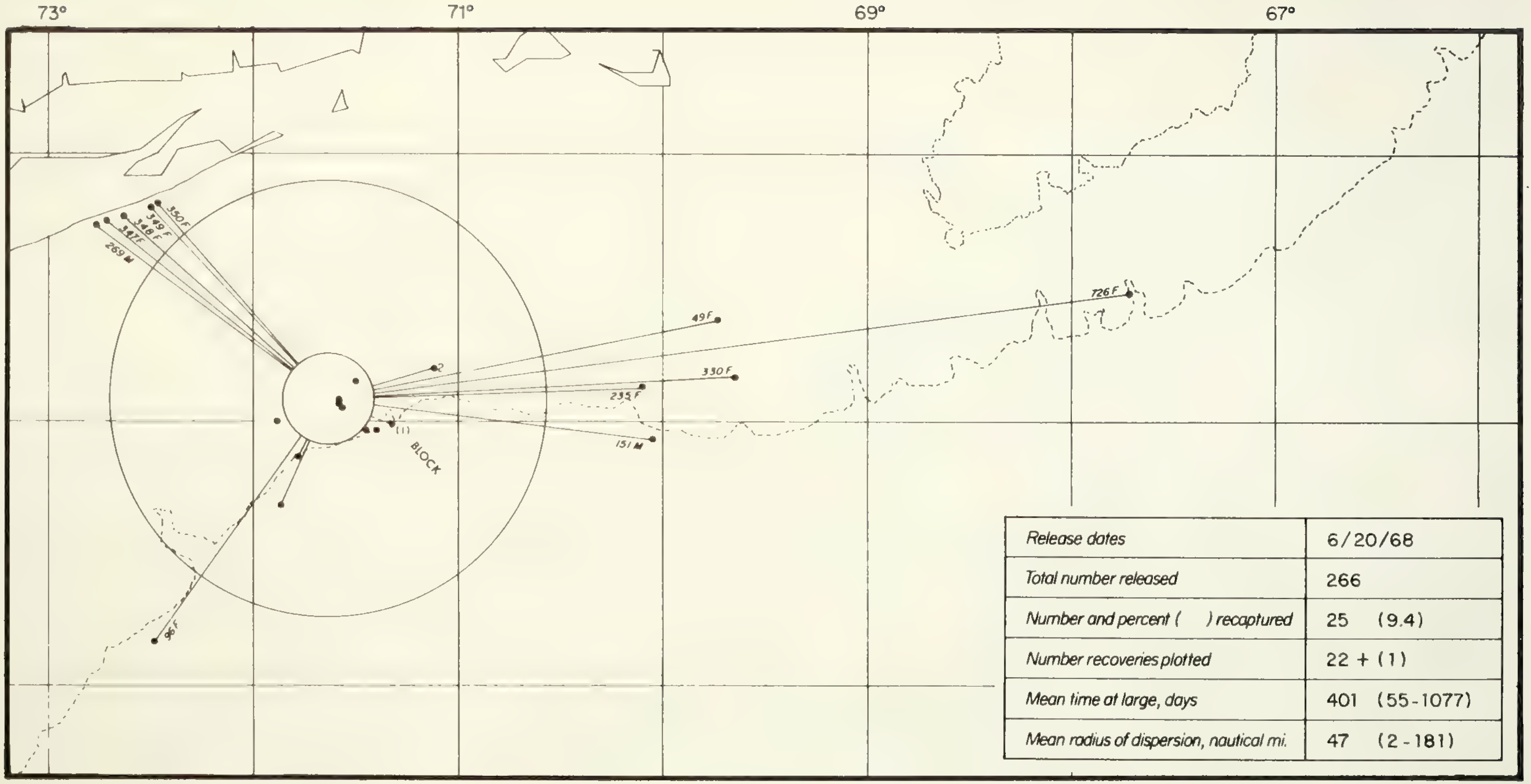
Release dates	6/17/68
Total number released	57
Number and percent ( ) recaptured	3 (5.3)
Number recoveries plotted	3
Mean time at large, days	231 (120-358)
Mean radius of dispersion, nautical mi.	30 (4-52)

Figure 14.—Recoveries from composite station 12.



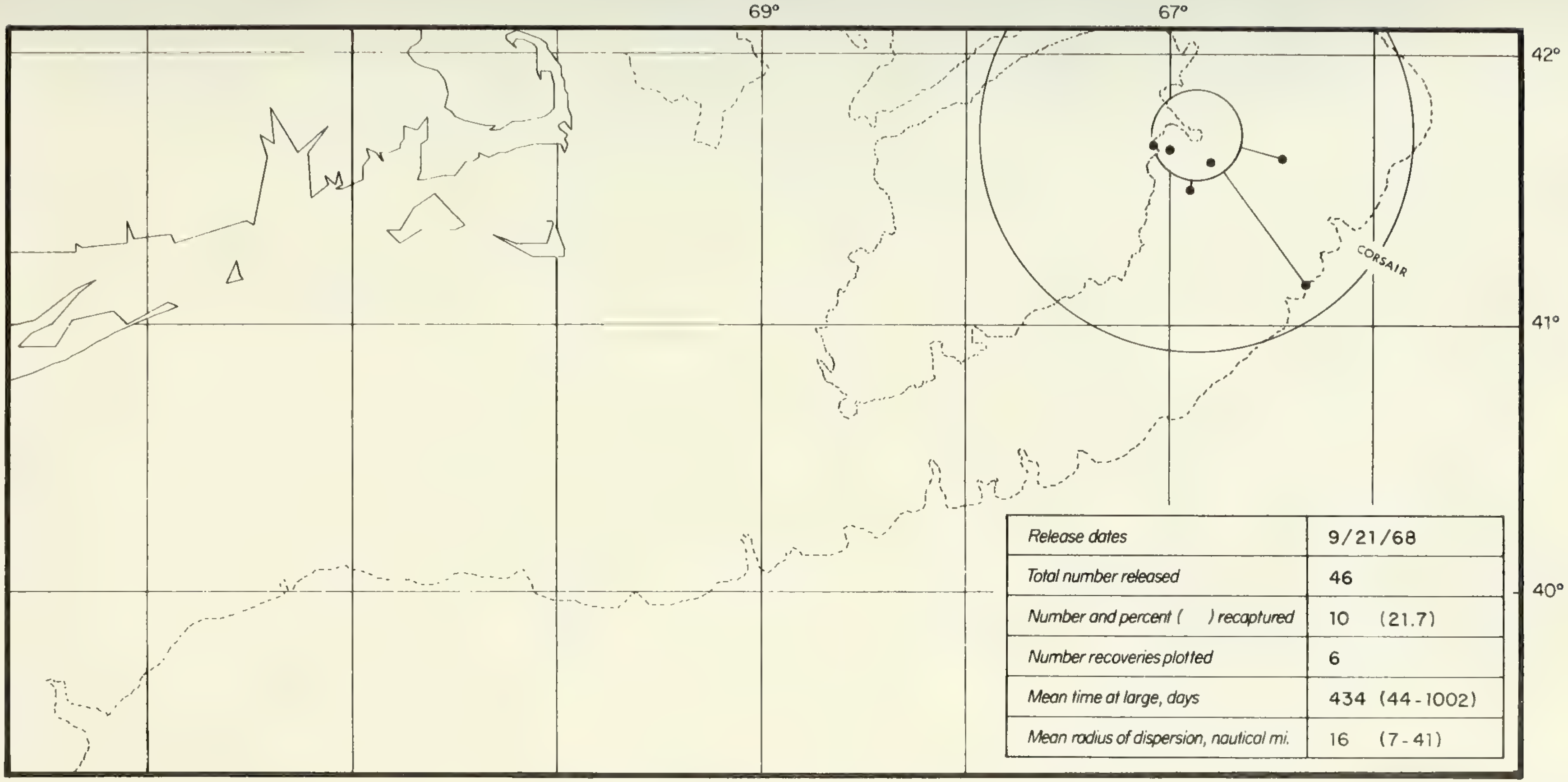
Release dates	6/18 - 19/68
Total number released	482
Number and percent ( ) recaptured	40 (8.3)
Number recoveries plotted	23 + (3)
Mean time at large, days	484 (14-1360)
Mean radius of dispersion, nautical mi.	52 (9-108)

Figure 15.—Recoveries from composite station 13.



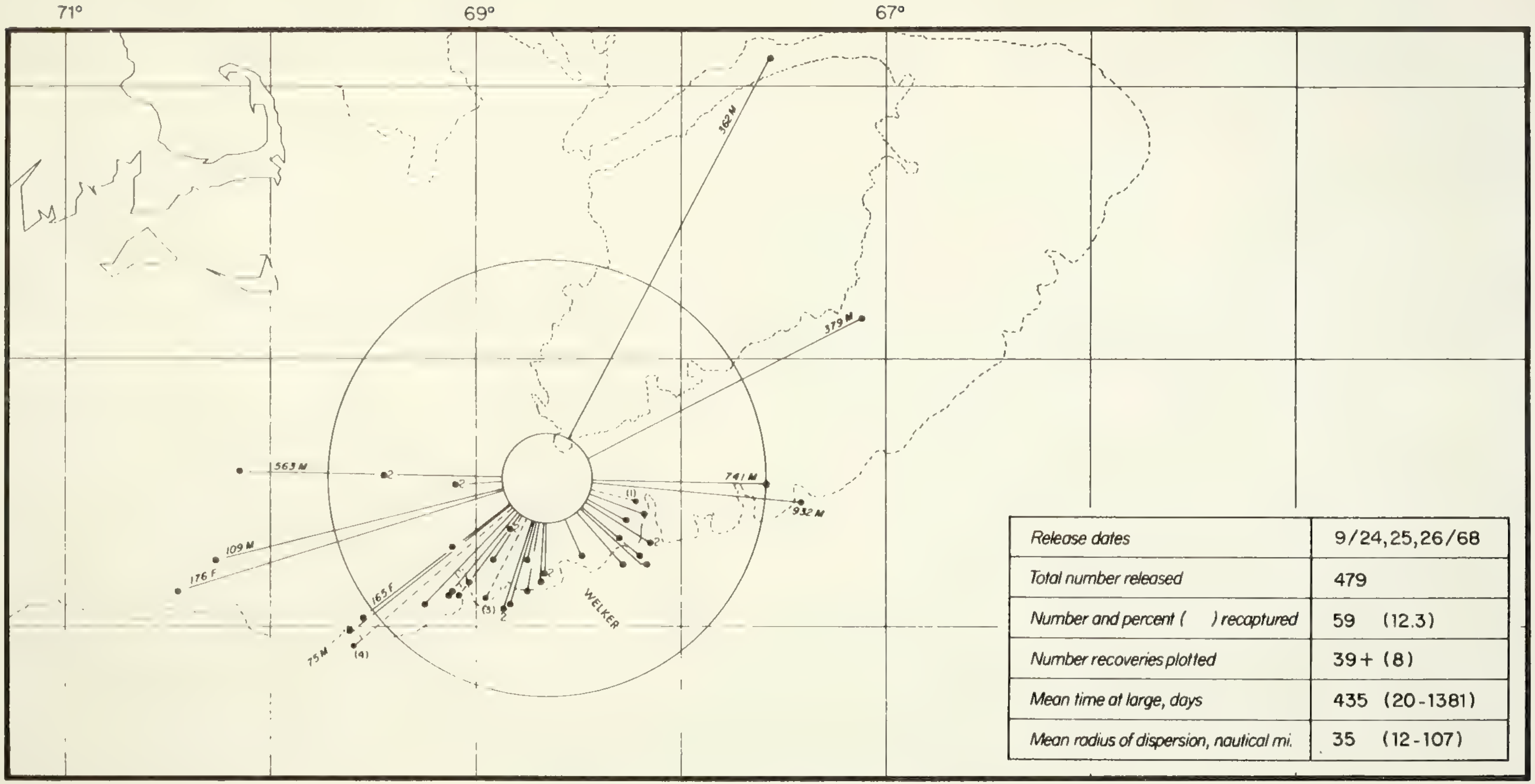
Release dates	6/20/68
Total number released	266
Number and percent ( ) recaptured	25 (9.4)
Number recoveries plotted	22 + (1)
Mean time at large, days	401 (55-1077)
Mean radius of dispersion, nautical mi.	47 (2-181)

Figure 16.—Recoveries from composite station 14.



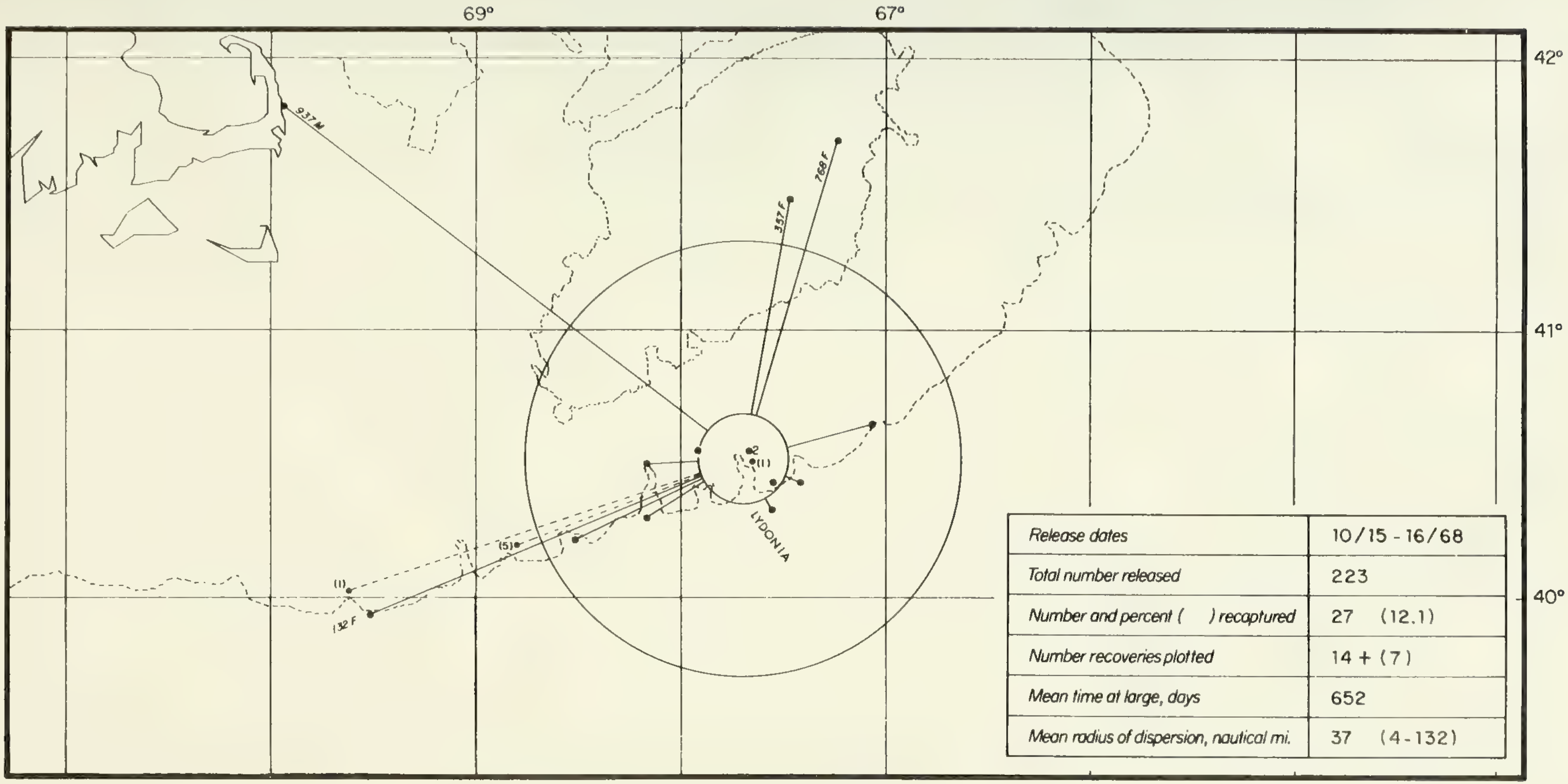
Release dates	9/21/68
Total number released	46
Number and percent ( ) recaptured	10 (21.7)
Number recoveries plotted	6
Mean time at large, days	434 (44-1002)
Mean radius of dispersion, nautical mi.	16 (7-41)

Figure 17.—Recoveries from composite station 15.



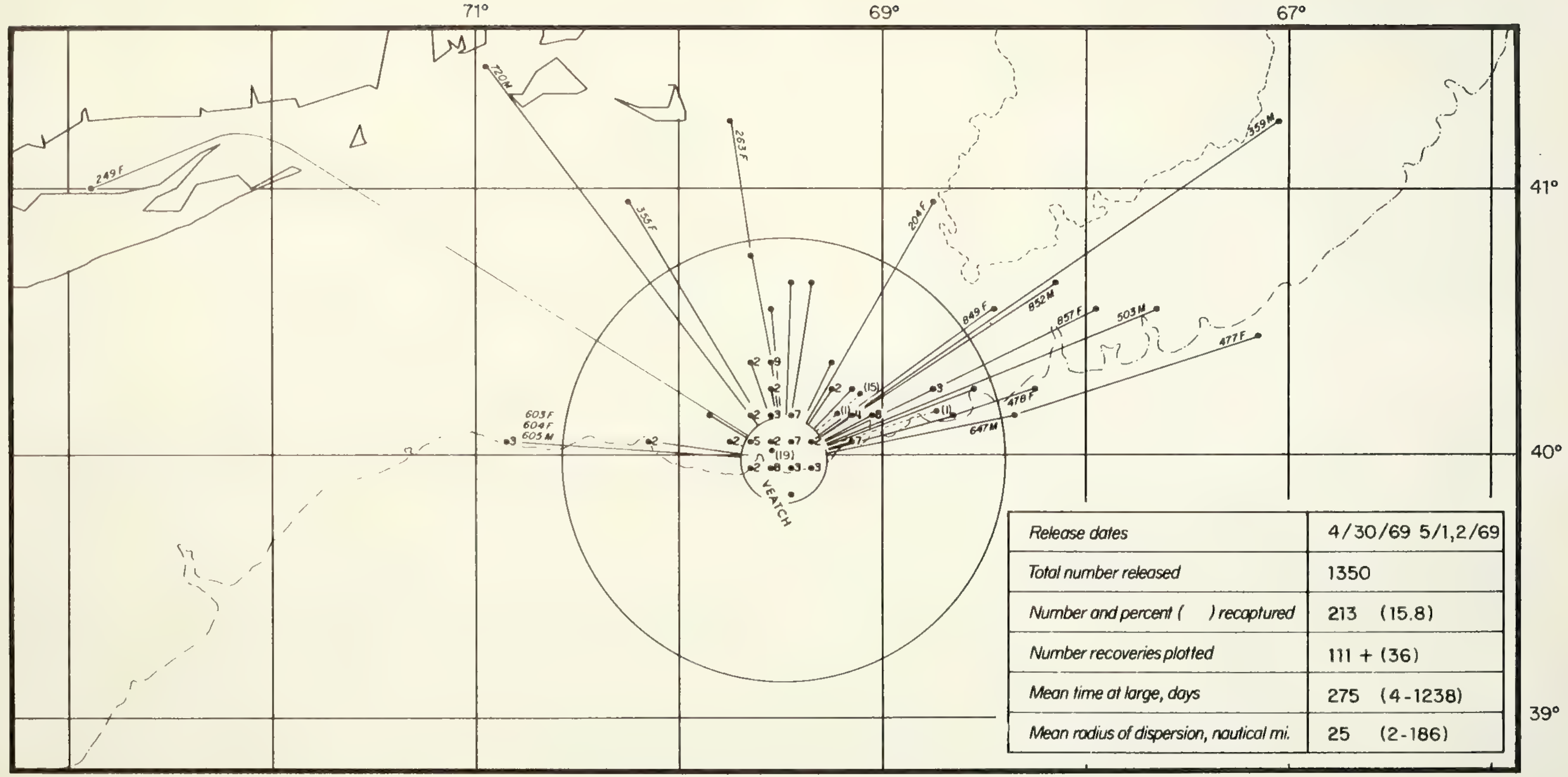
Release dates	9/24,25,26/68
Total number released	479
Number and percent ( ) recaptured	59 (12.3)
Number recoveries plotted	39+ (8)
Mean time at large, days	435 (20-1381)
Mean radius of dispersion, nautical mi.	35 (12-107)

Figure 18.—Recoveries from composite station 16.



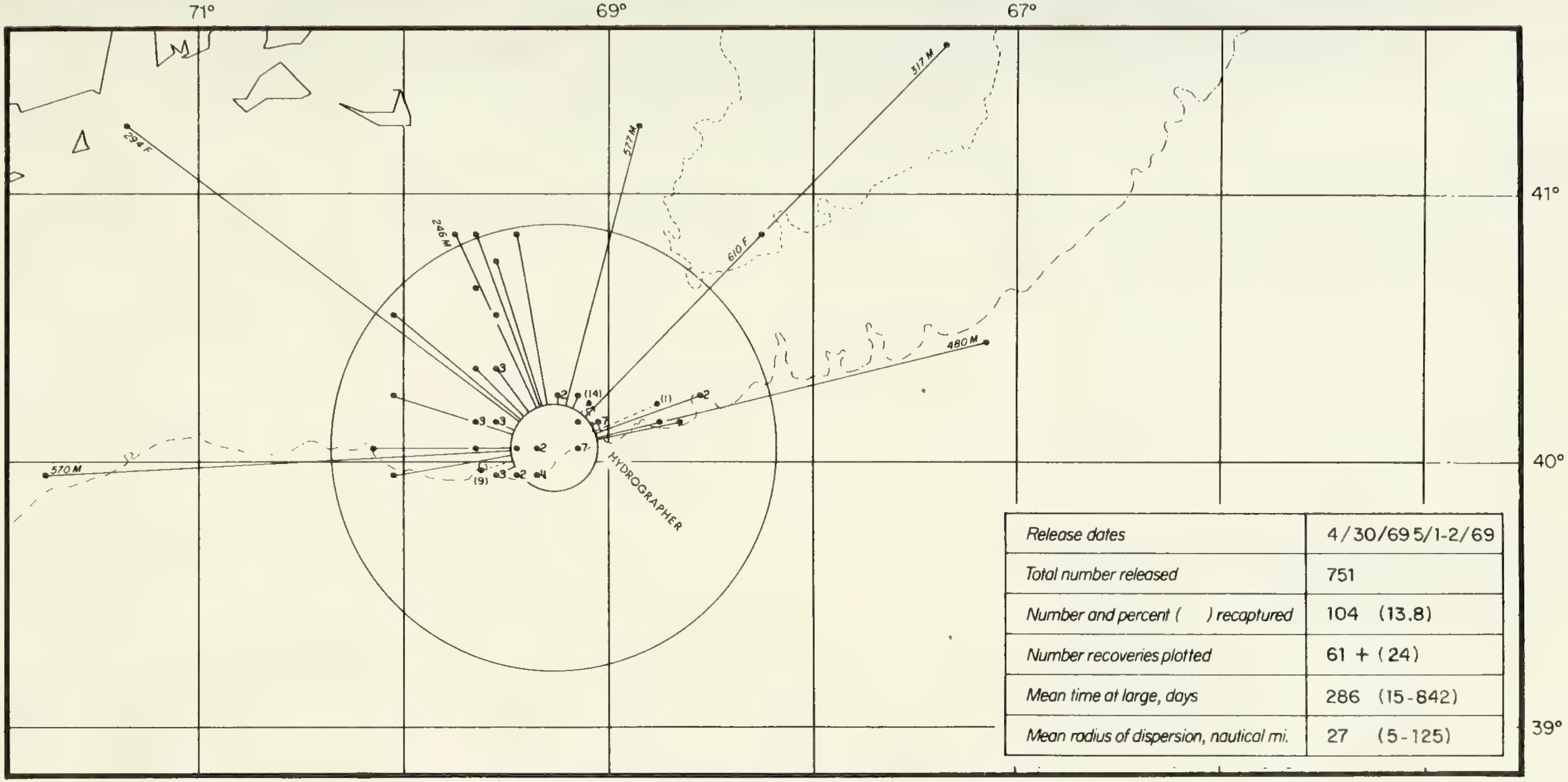
Release dates	10/15 - 16/68
Total number released	223
Number and percent ( ) recaptured	27 (12.1)
Number recoveries plotted	14 + (7)
Mean time at large, days	652
Mean radius of dispersion, nautical mi.	37 (4-132)

Figure 19.—Recoveries from composite station 17.



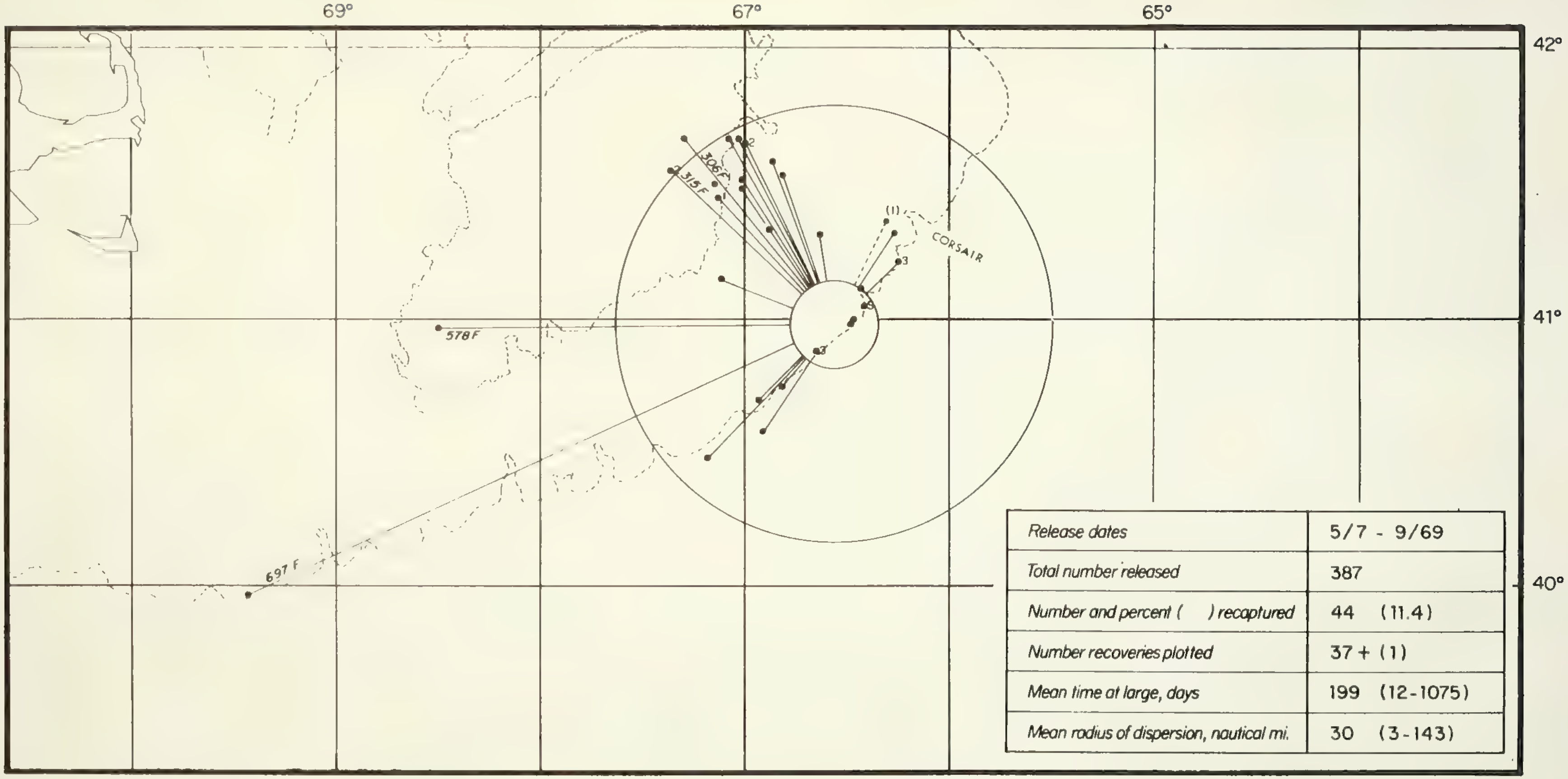
Release dates	4/30/69 5/1,2/69
Total number released	1350
Number and percent ( ) recaptured	213 (15.8)
Number recoveries plotted	111 + (36)
Mean time at large, days	275 (4-1238)
Mean radius of dispersion, nautical mi.	25 (2-186)

Figure 20.—Recoveries from composite station 18 plotted by 6-minute squares.



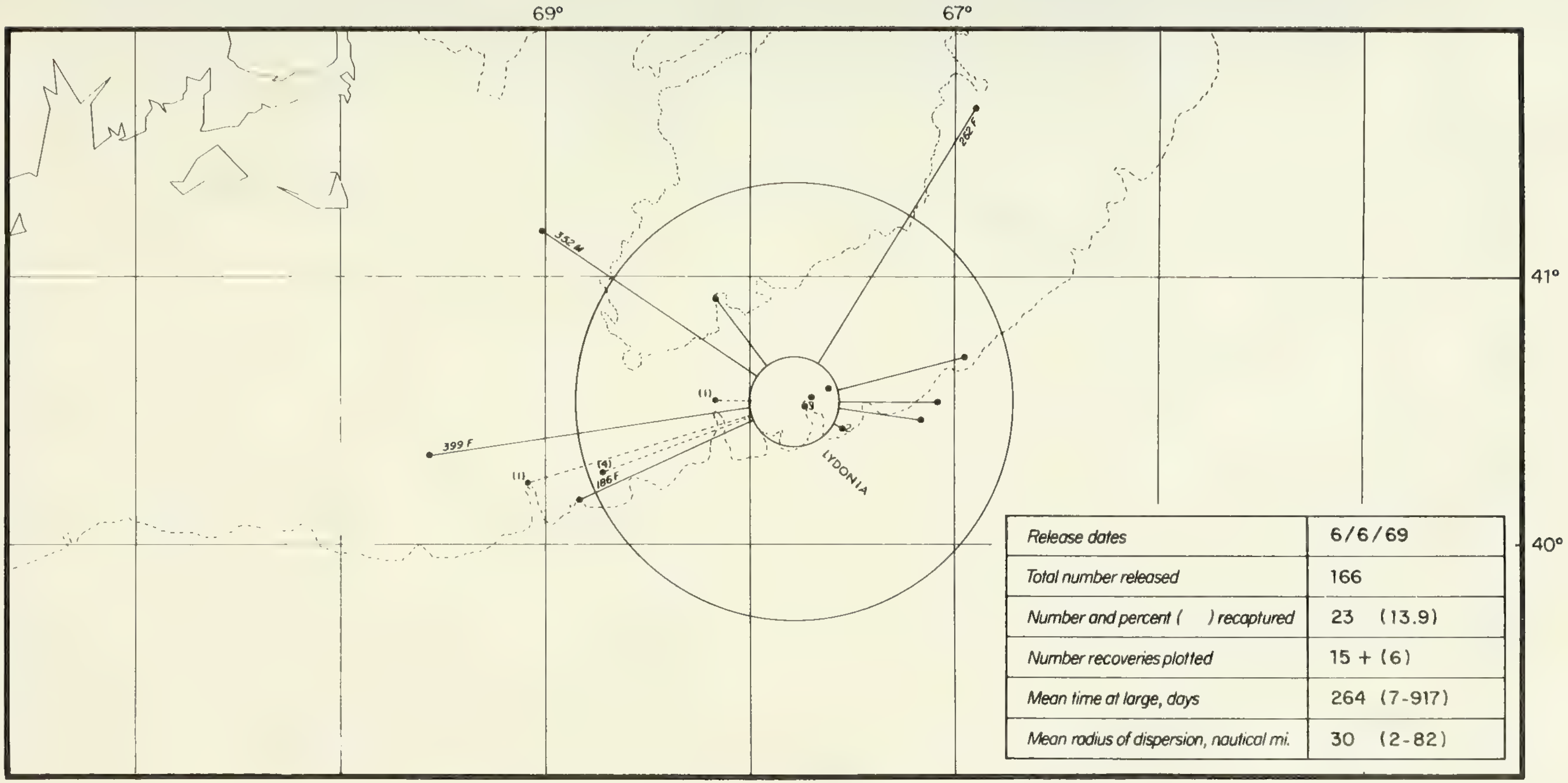
Release dates	4/30/69 5/1-2/69
Total number released	751
Number and percent ( ) recaptured	104 (13.8)
Number recoveries plotted	61 + (24)
Mean time at large, days	286 (15-842)
Mean radius of dispersion, nautical mi.	27 (5-125)

Figure 21.—Recoveries from composite station 19 plotted by 6-minute squares.



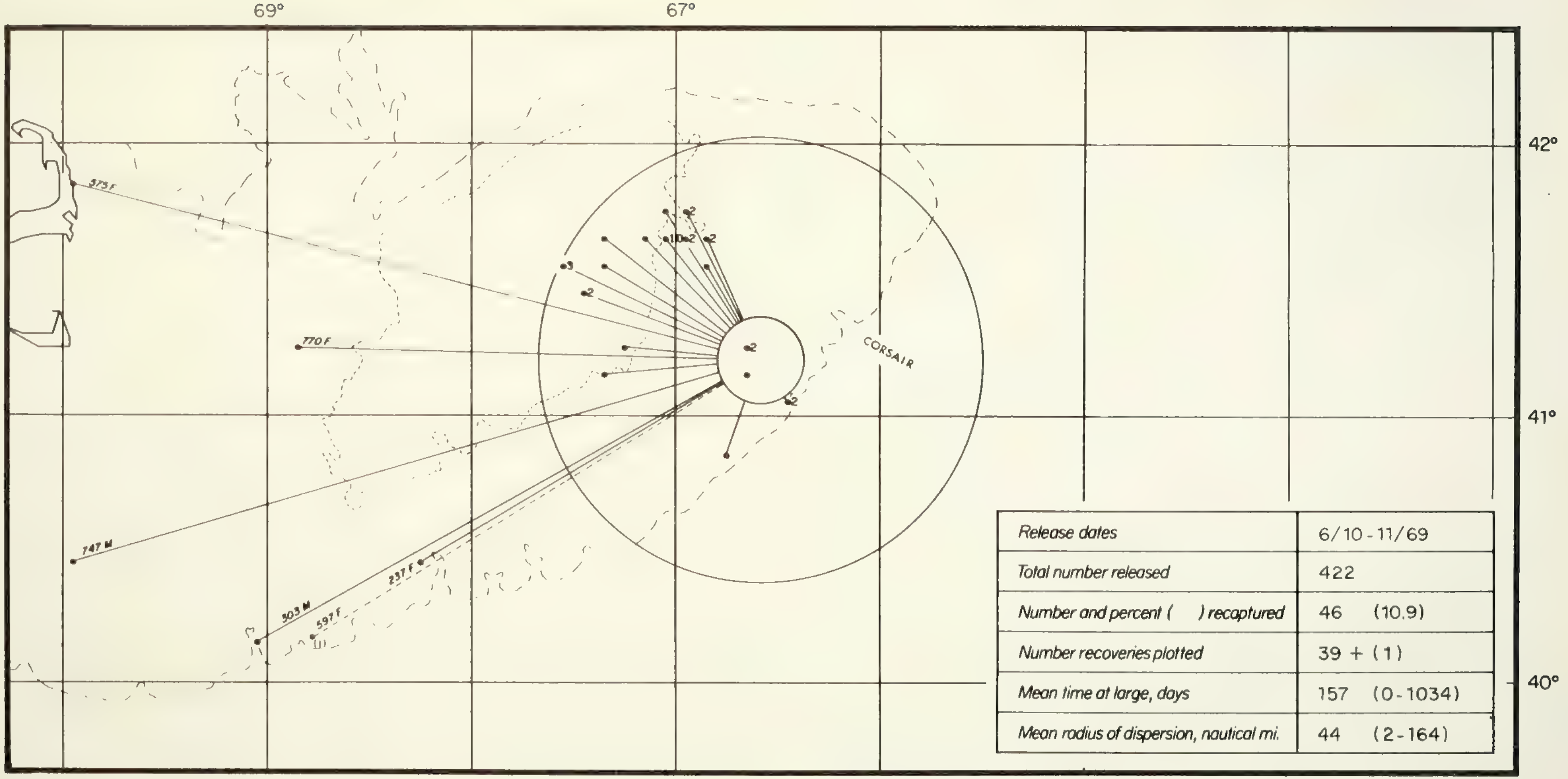
Release dates	5/7 - 9/69
Total number released	387
Number and percent ( ) recaptured	44 (11.4)
Number recoveries plotted	37 + (1)
Mean time at large, days	199 (12-1075)
Mean radius of dispersion, nautical mi.	30 (3-143)

Figure 22.—Recoveries from composite station 20.



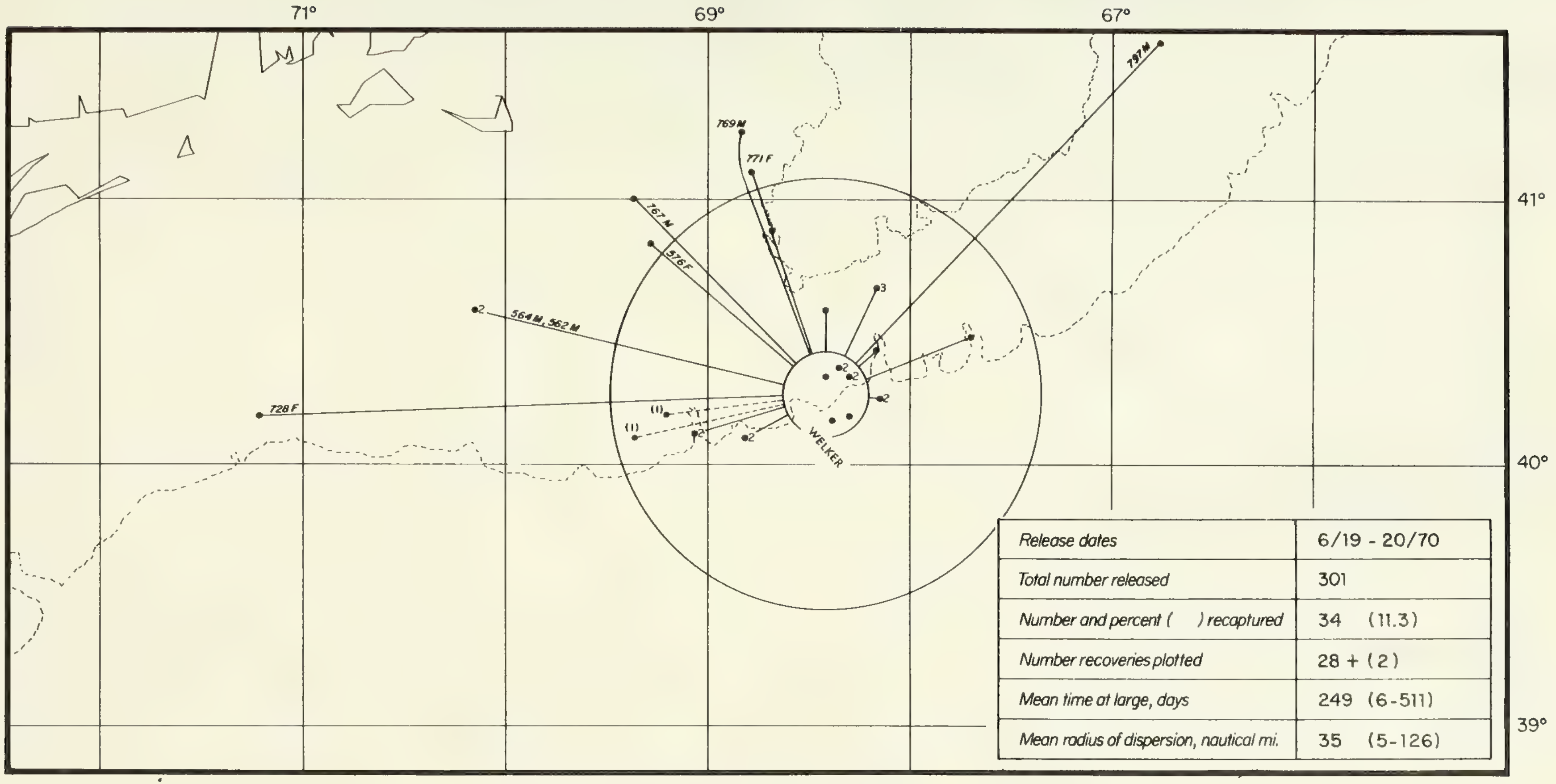
Release dates	6/6/69
Total number released	166
Number and percent ( ) recaptured	23 (13.9)
Number recoveries plotted	15 + (6)
Mean time at large, days	264 (7-917)
Mean radius of dispersion, nautical mi.	30 (2-82)

Figure 23.—Recoveries from composite station 21.



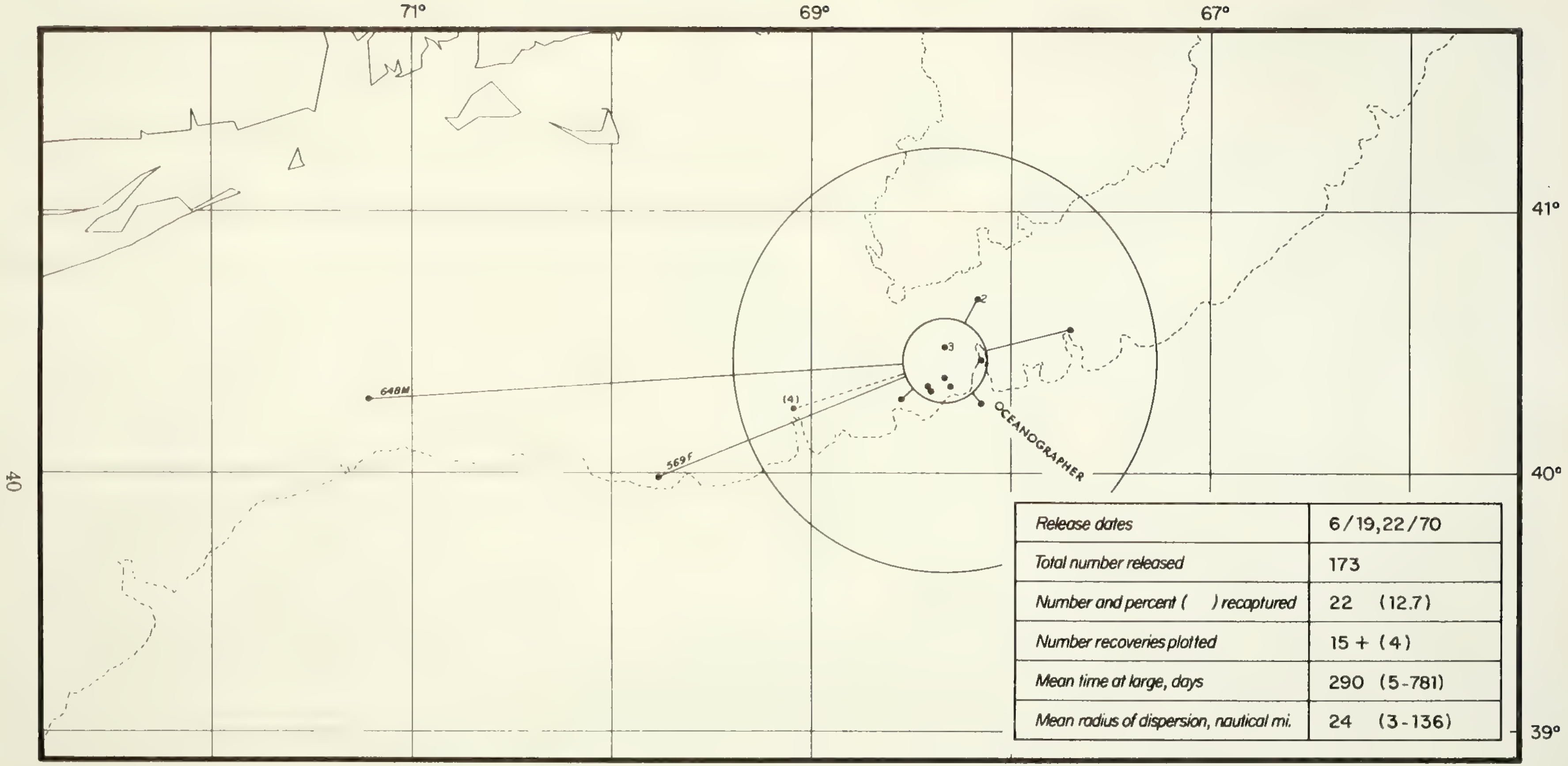
Release dates	6/10 - 11/69
Total number released	422
Number and percent ( ) recaptured	46 (10.9)
Number recoveries plotted	39 + (1)
Mean time at large, days	157 (0 - 1034)
Mean radius of dispersion, nautical mi.	44 (2 - 164)

Figure 24.—Recoveries from composite station 22 plotted by 6-minute squares.



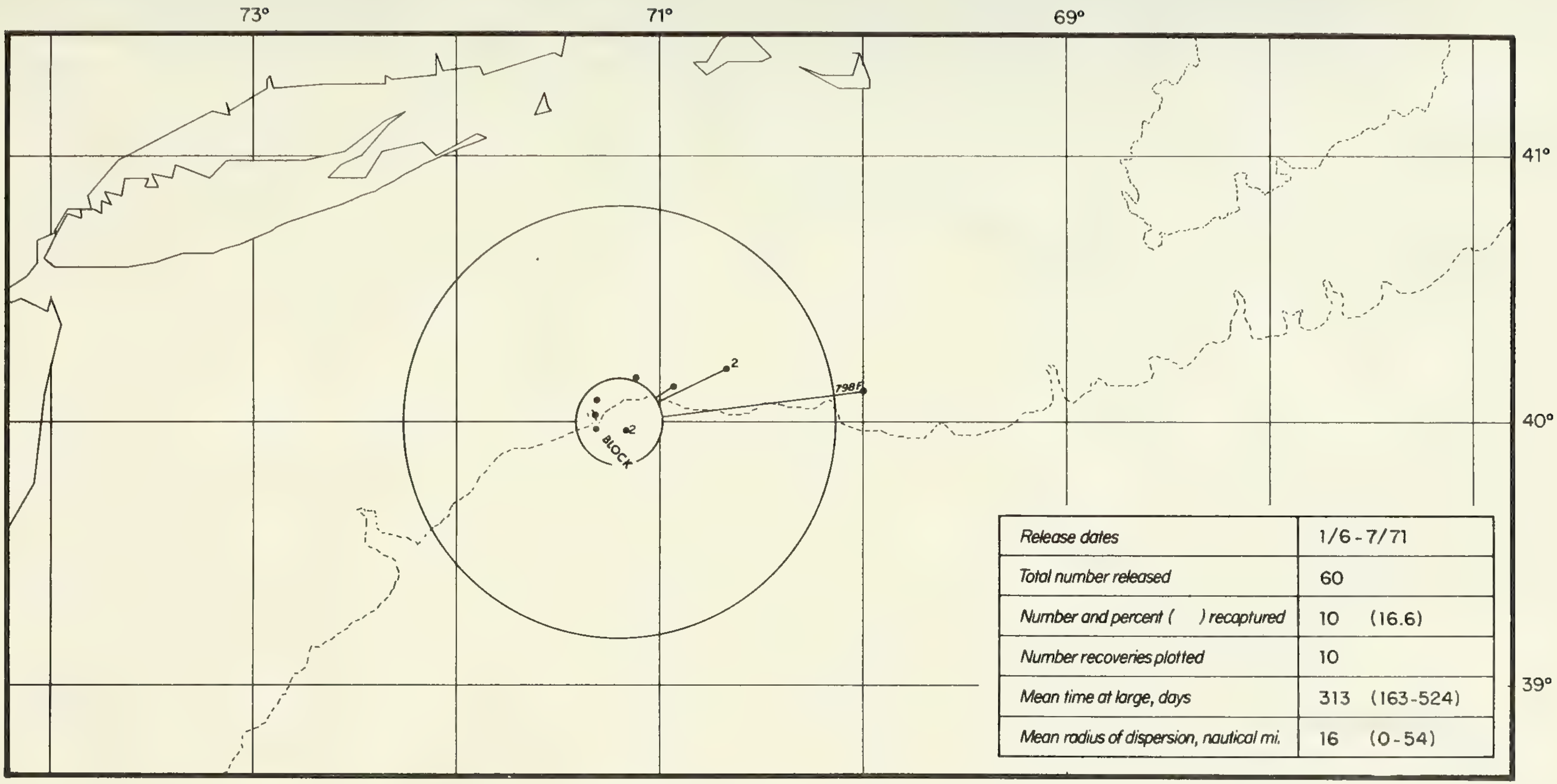
Release dates	6/19 - 20/70
Total number released	301
Number and percent ( ) recaptured	34 (11.3)
Number recoveries plotted	28 + (2)
Mean time at large, days	249 (6-511)
Mean radius of dispersion, nautical mi.	35 (5-126)

Figure 25.—Recoveries from composite station 23.



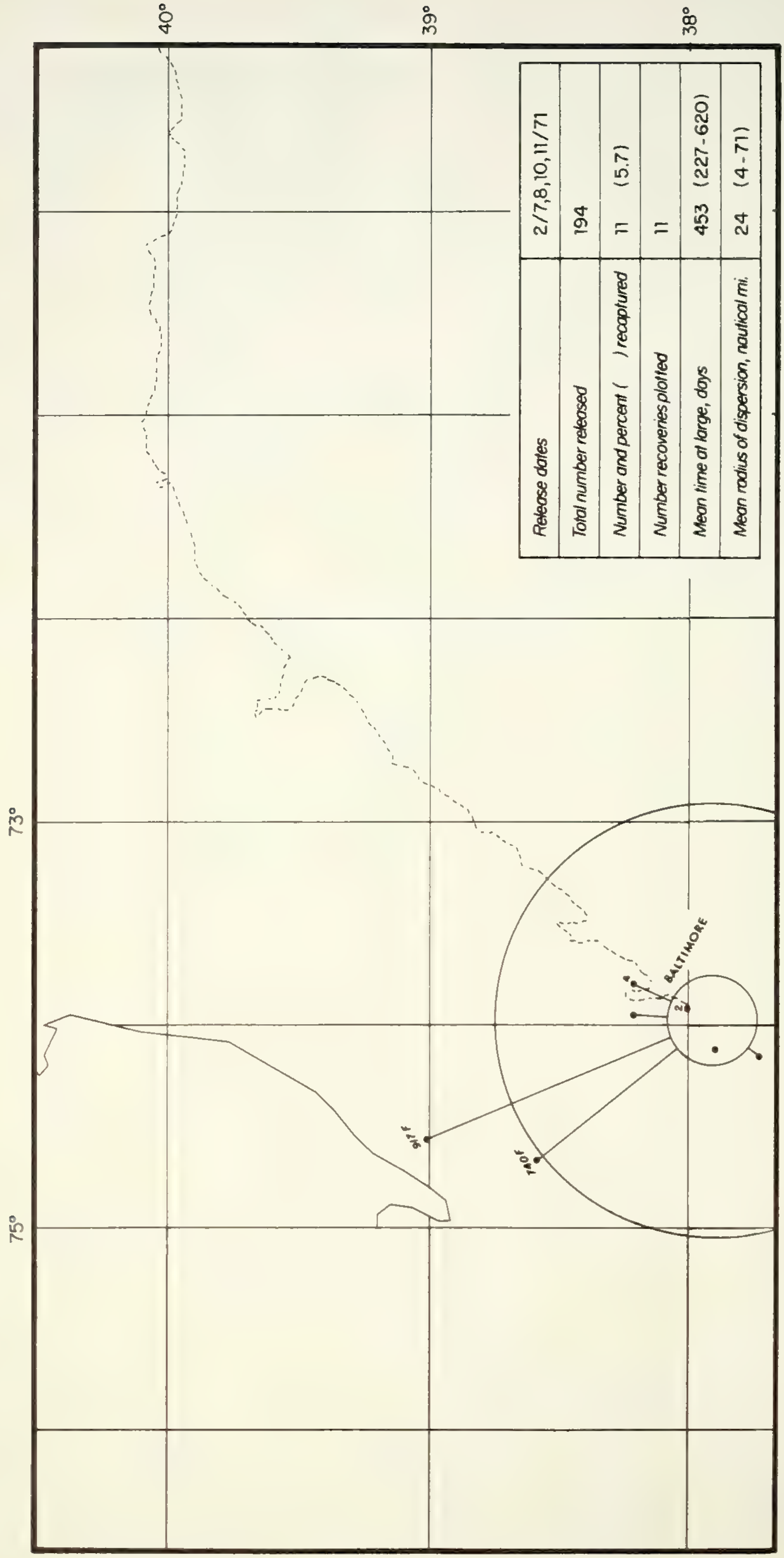
Release dates	6/19,22/70
Total number released	173
Number and percent ( ) recaptured	22 (12.7)
Number recoveries plotted	15 + (4)
Mean time at large, days	290 (5-781)
Mean radius of dispersion, nautical mi.	24 (3-136)

Figure 26.—Recoveries from composite station 24.



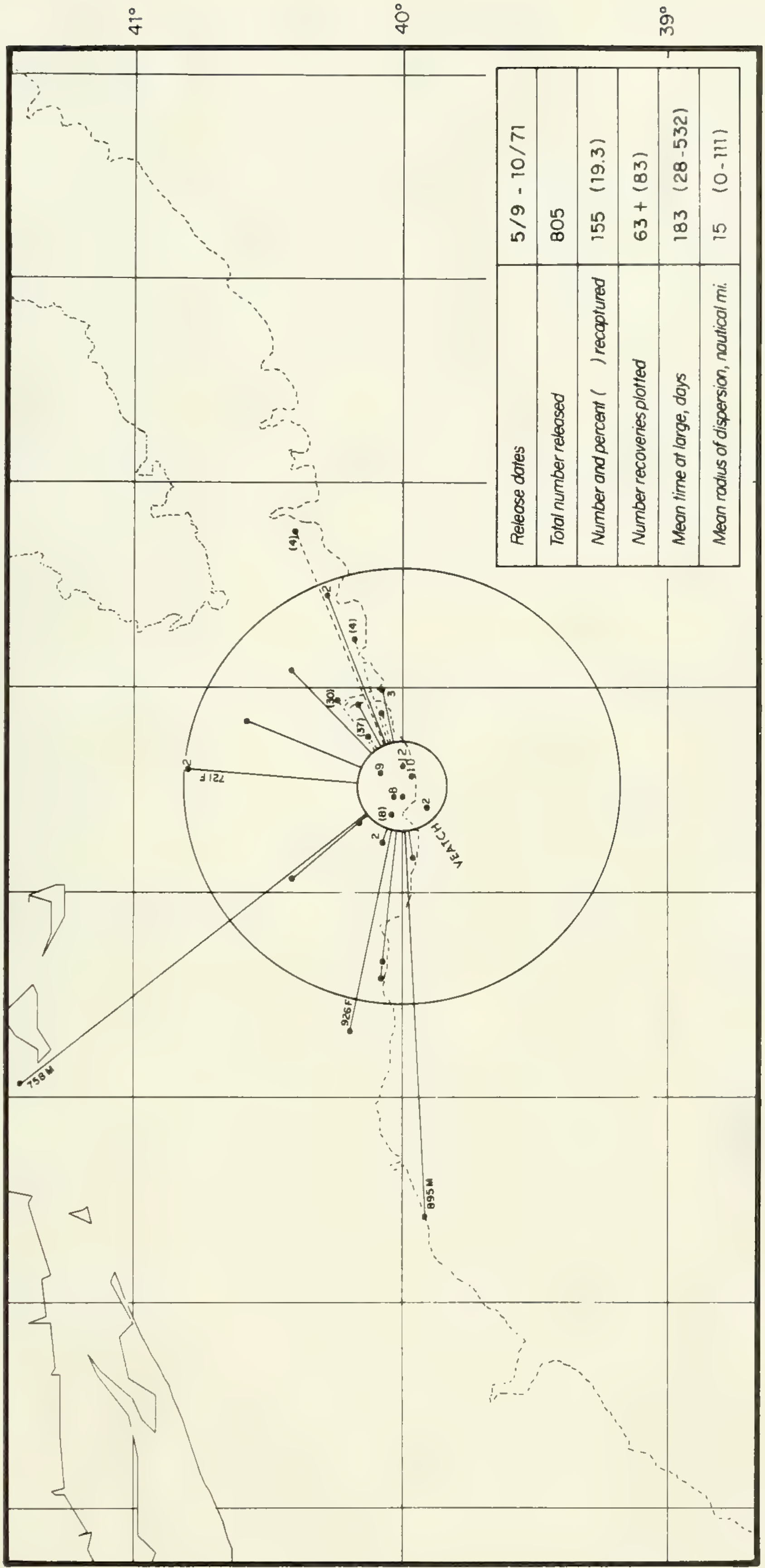
Release dates	1/6 - 7/71
Total number released	60
Number and percent ( ) recaptured	10 (16.6)
Number recoveries plotted	10
Mean time at large, days	313 (163-524)
Mean radius of dispersion, nautical mi.	16 (0-54)

Figure 27.—Recoveries from composite station 25.



Release dates	2/7,8,10,11/71
Total number released	194
Number and percent ( ) recaptured	11 (5.7)
Number recoveries plotted	11
Mean time at large, days	453 (227-620)
Mean radius of dispersion, nautical mi.	24 (4-71)

Figure 28.—Recoveries from composite station 27.



Release dates	5/9 - 10/71
Total number released	805
Number and percent ( ) recaptured	155 (19.3)
Number recoveries plotted	63 + (83)
Mean time at large, days	183 (28-532)
Mean radius of dispersion, nautical mi.	15 (0-111)

Figure 29.—Recoveries from composite station 29 plotted by 6-minute squares.

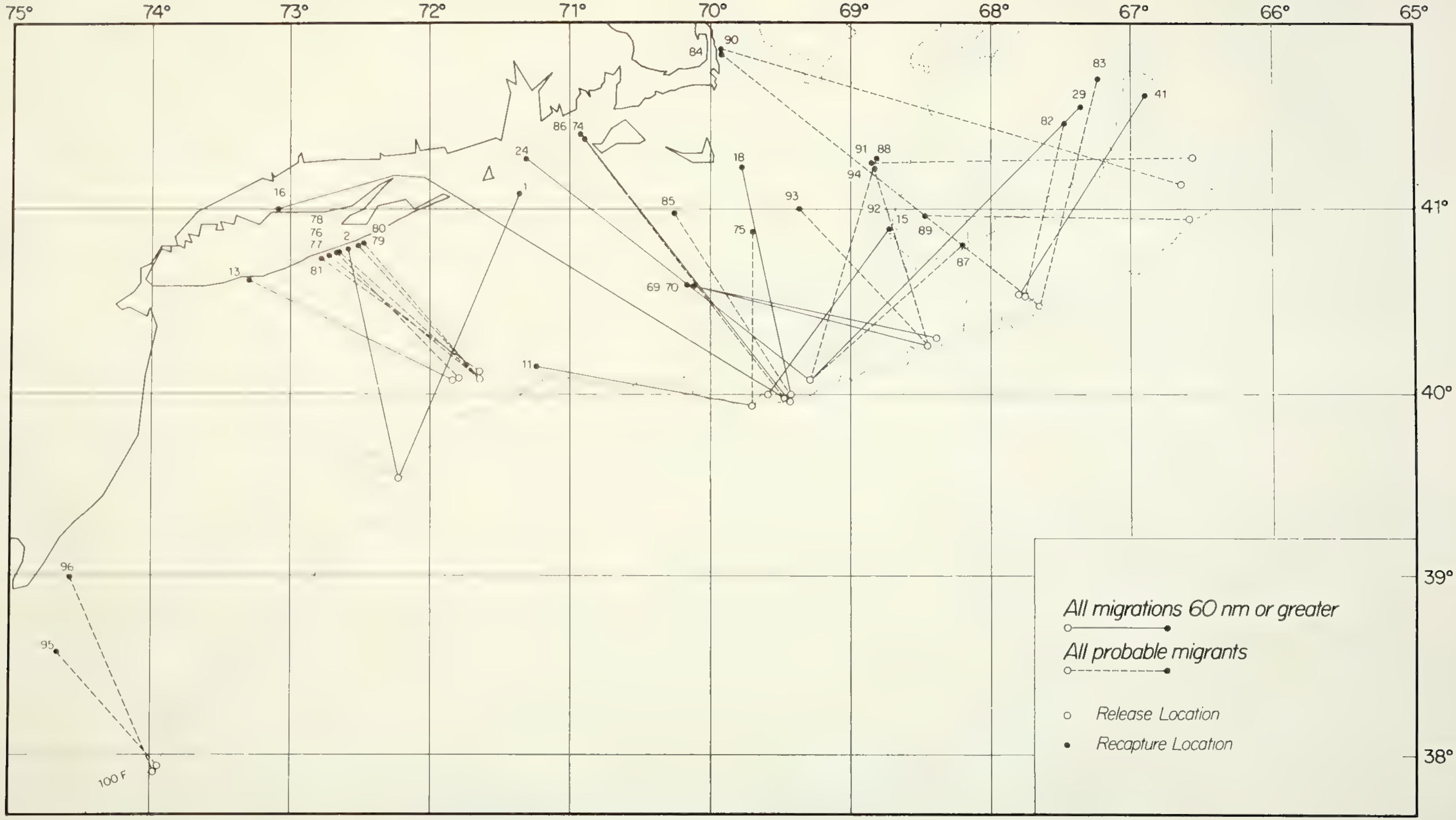


Figure 30.—Shoalward migrations of 60 nautical miles (111 km) or greater and probable shoalward migrations of 50 nautical miles (92.7 km), Baltimore Canyon to Corsair Canyon.

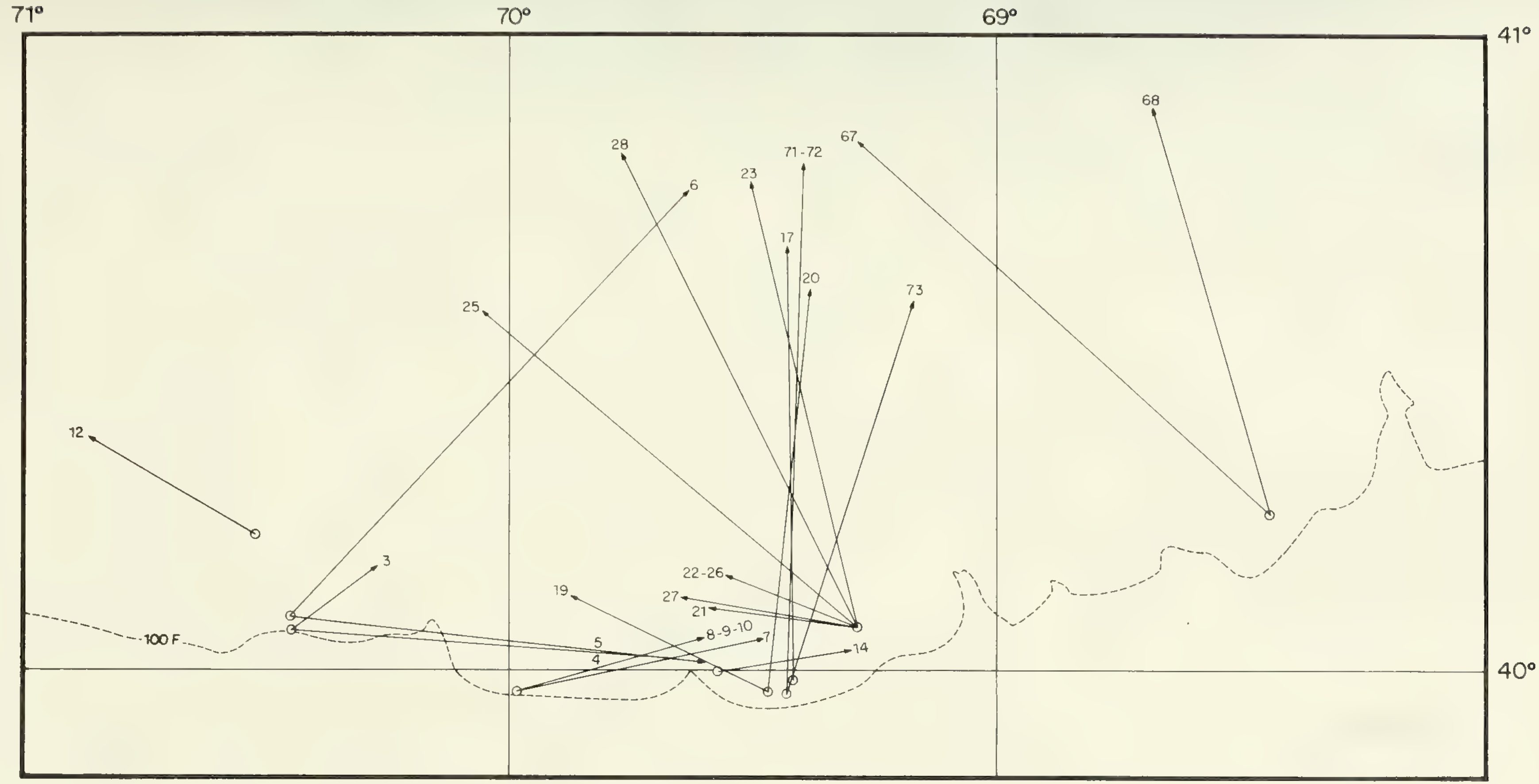


Figure 31.—Shoalward migrations greater than 10 nautical miles (18.5 km) but less than 60 nautical miles (111 km), Block Canyon to Oceanographer Canyon.

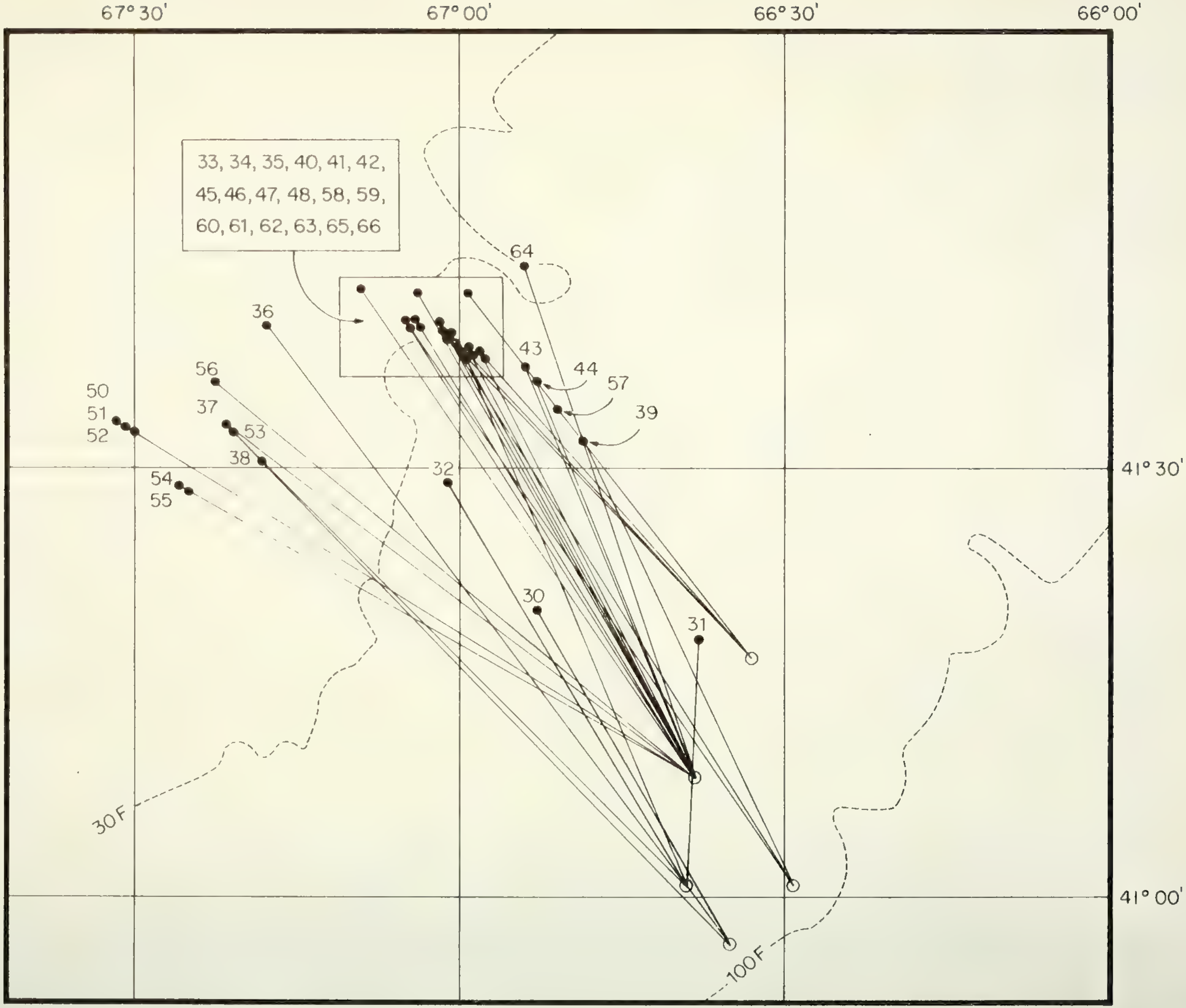


Figure 32.—Shoalward migrations greater than 10 nautical miles (18.5 km) but less than 60 nautical miles (111 km) originating near Corsair Canyon.

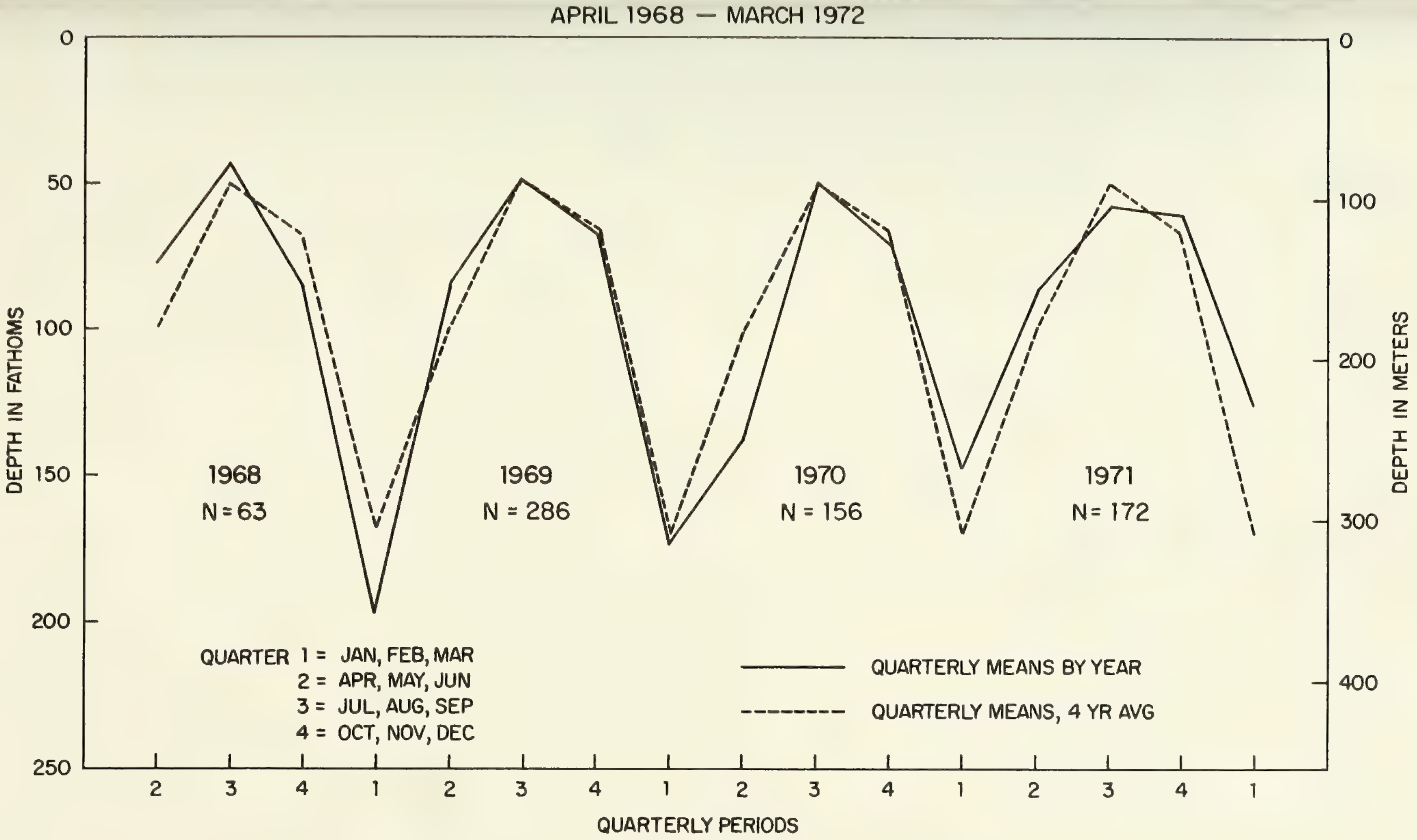


Figure 33.—Mean depth of recapture of tagged lobsters by quarterly periods, 1968-71.

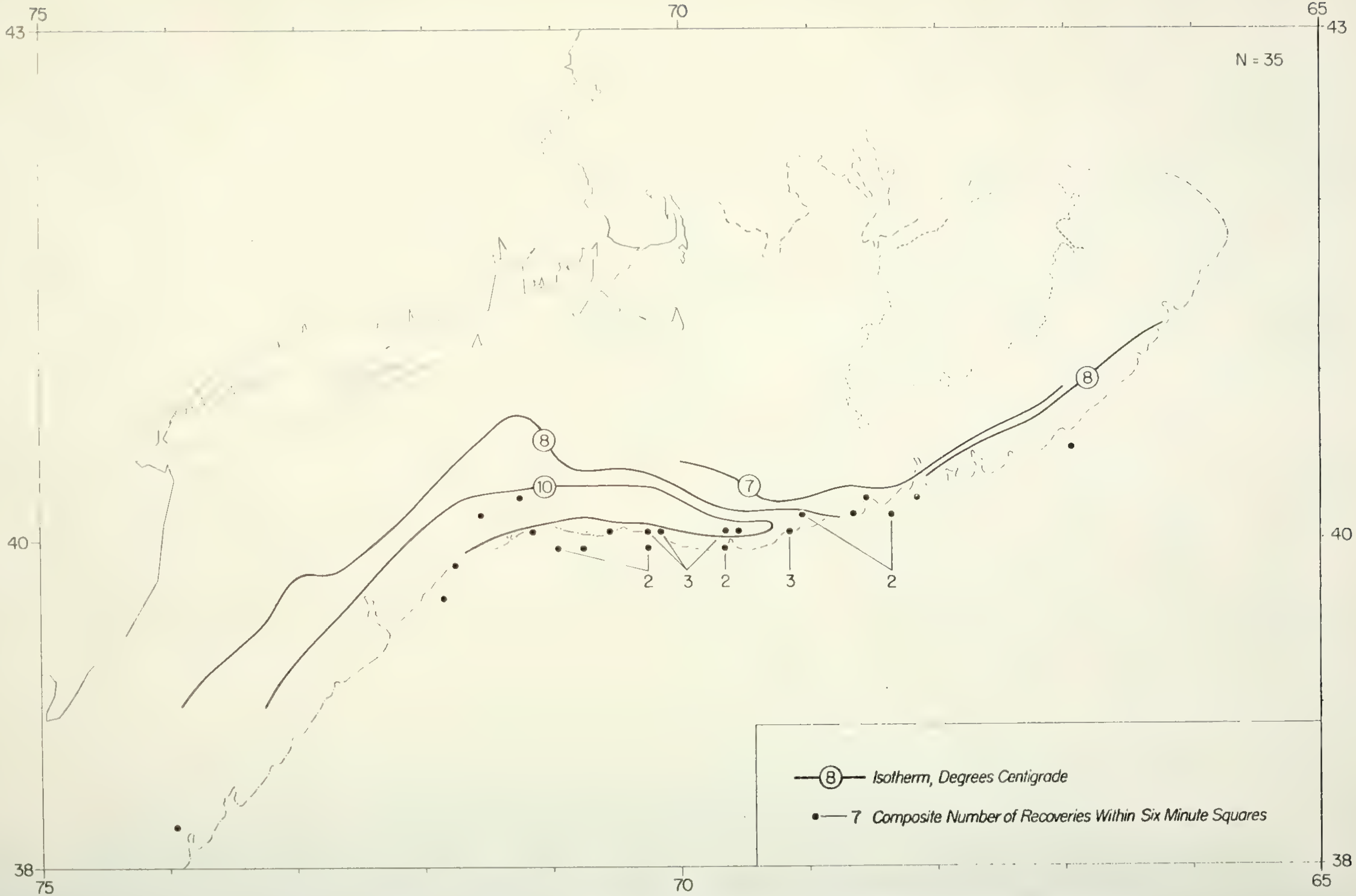

75
70
65
43
40
38
N = 35
8
7
10
8
2
3
2
3
2
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 34.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—January.

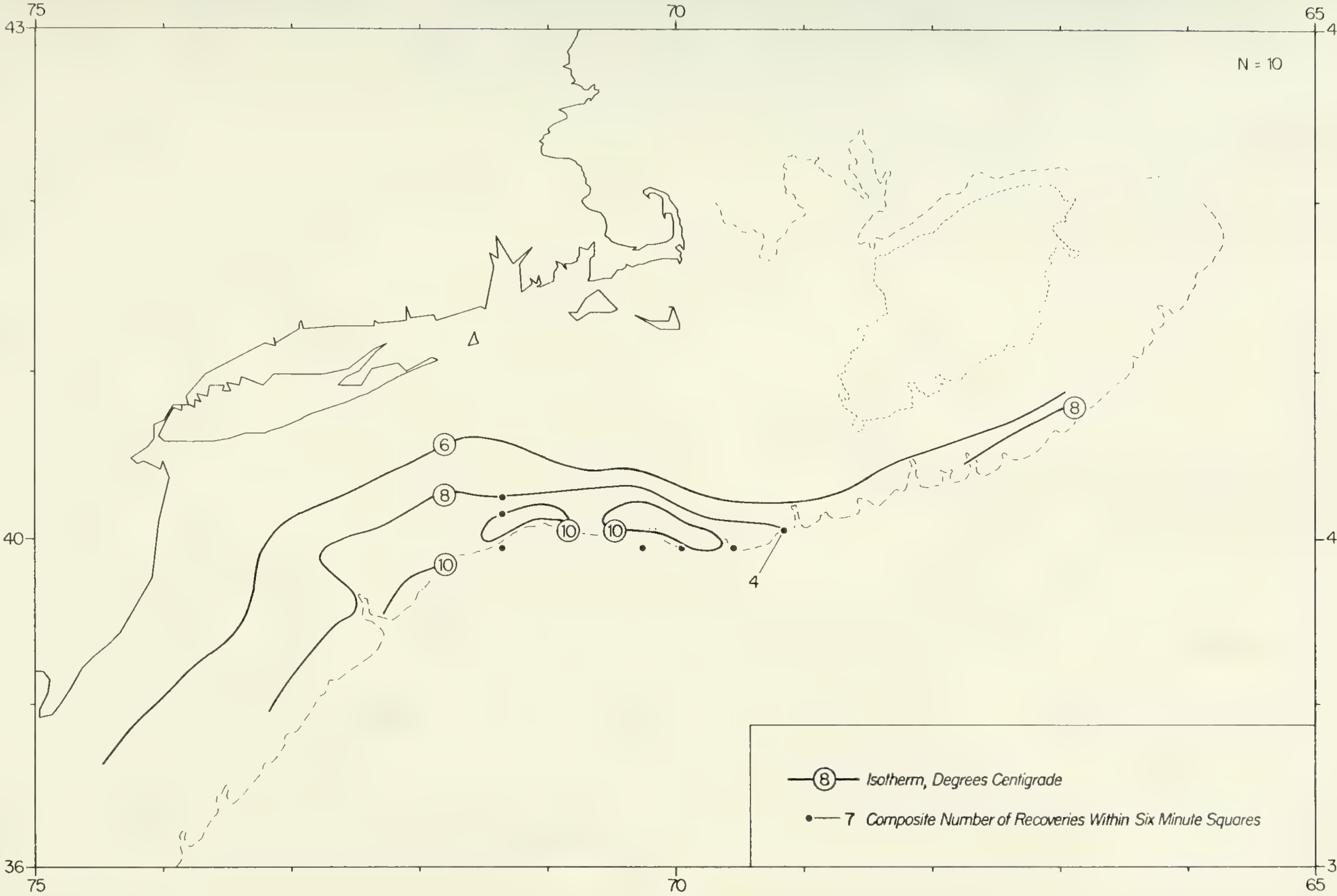

75
70
65
43
40
36
N = 10
6
8
10
10
10
4
8
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 35.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—February.

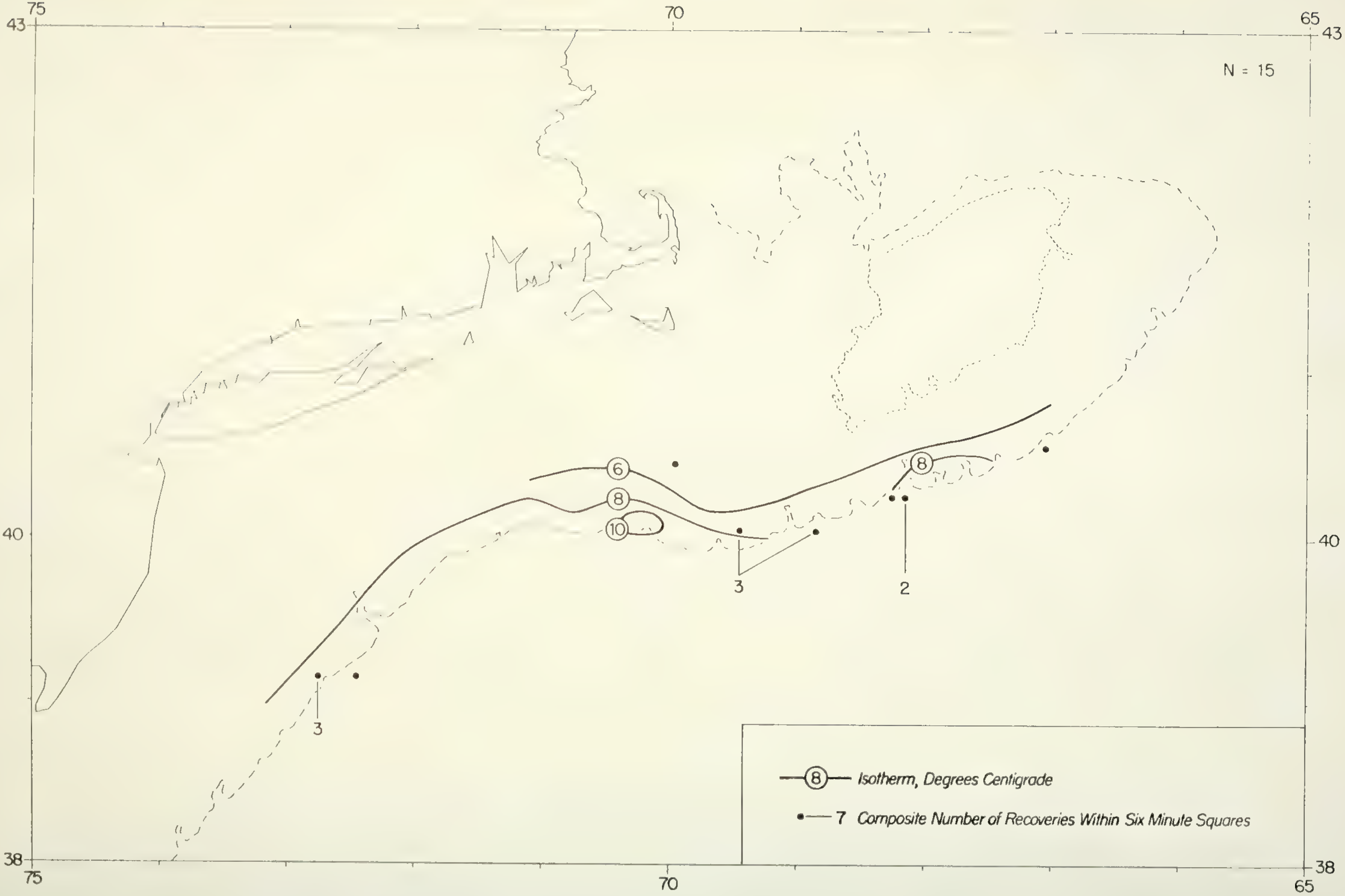

75
70
65
43
43
N = 15
40
40
38
38
75
70
65
6
8
10
8
3
2
3
8 Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 36.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—March.

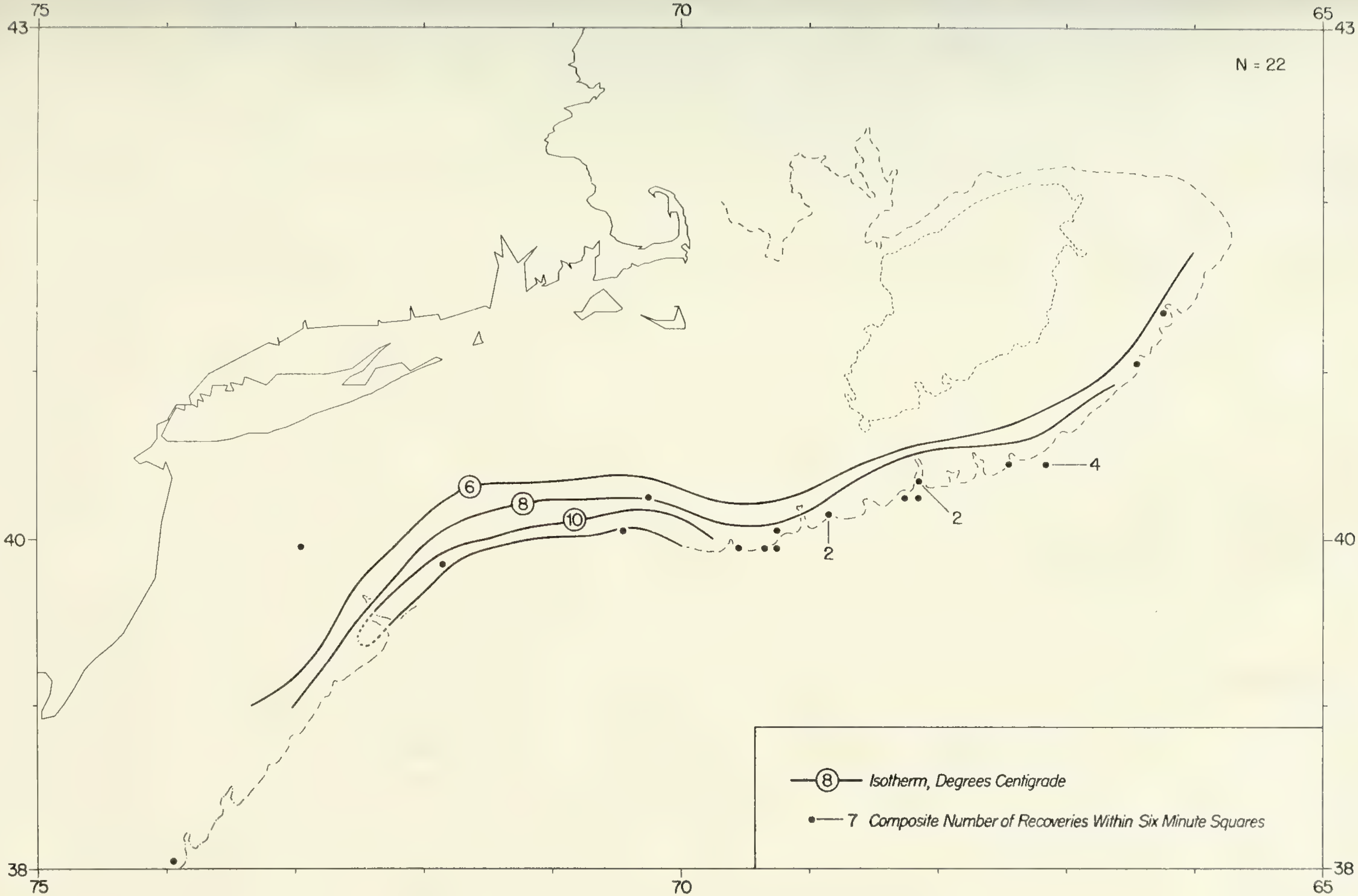

75
70
65
43
40
38
N = 22
6
8
10
4
2
2
8 Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 37.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—April.

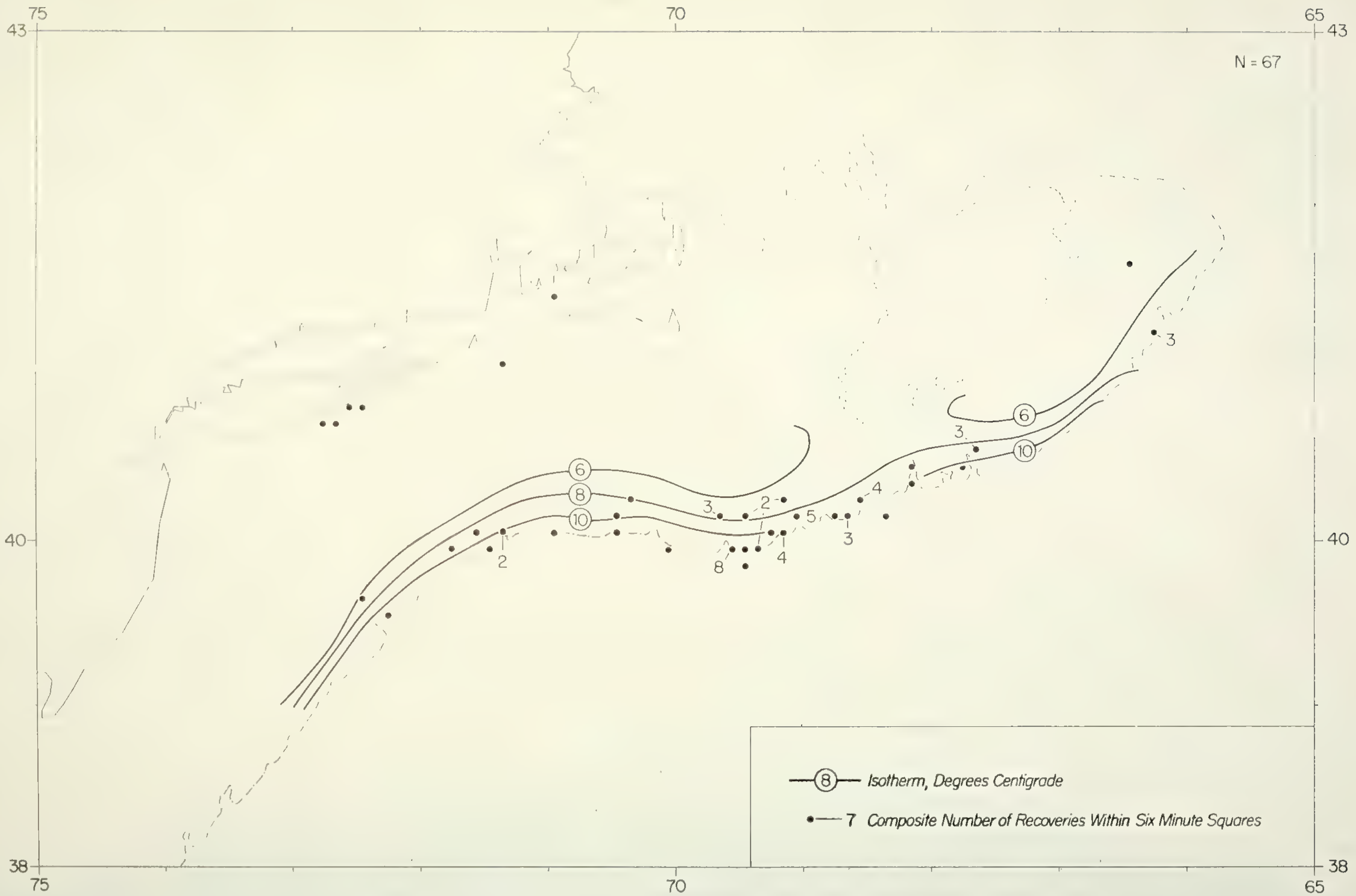

75
70
65
43
40
38
N = 67
3
6
10
3
4
3
5
2
3
4
8
6
8
10
2
8 Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 38.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—May.

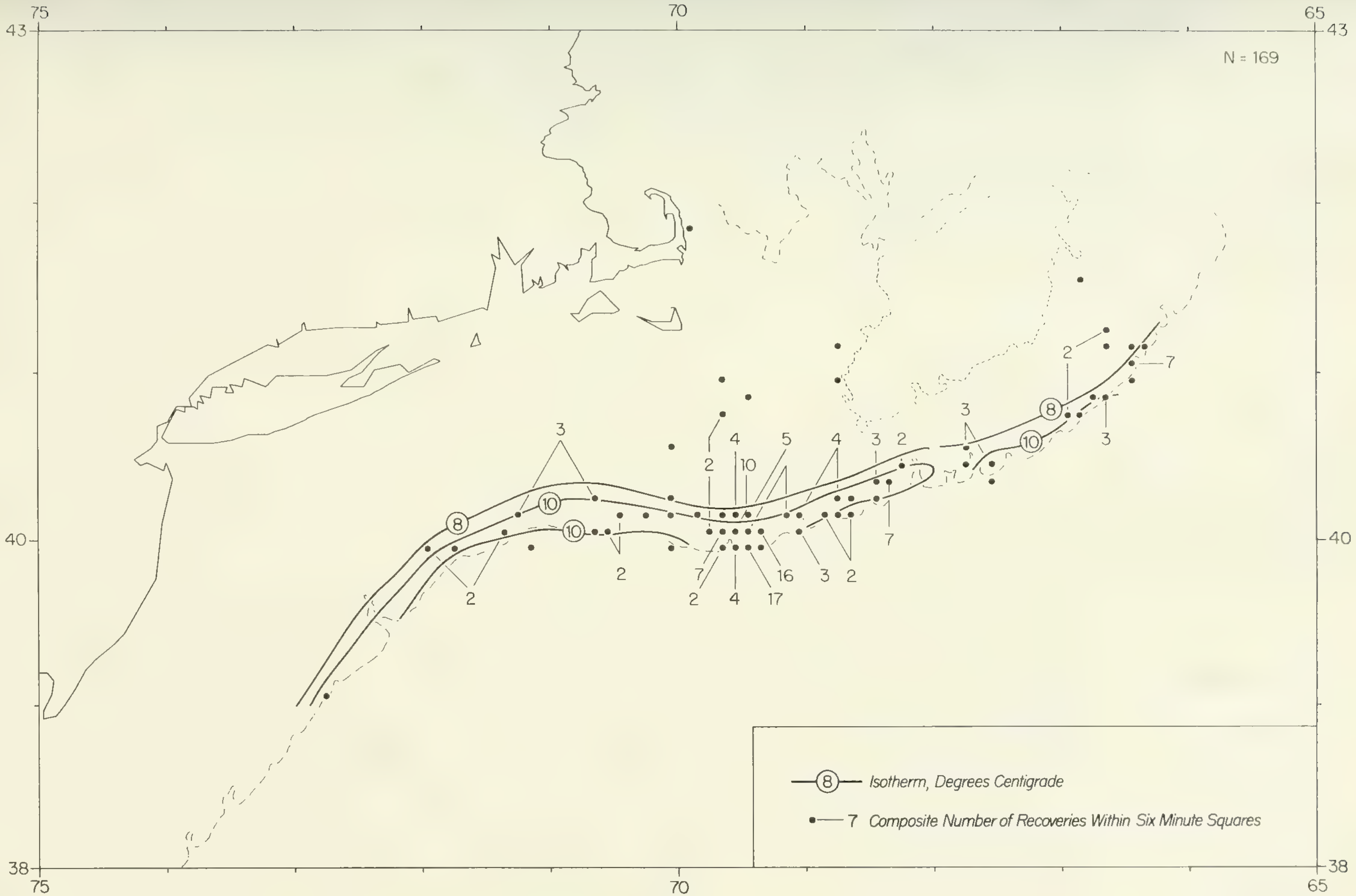

75
70
65
43
40
38
N = 169
3
8
10
10
2
2
2
2
4
10
5
4
3
2
3
8
10
3
2
7
7
2
4
17
16
3
2
7
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 39.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—June.

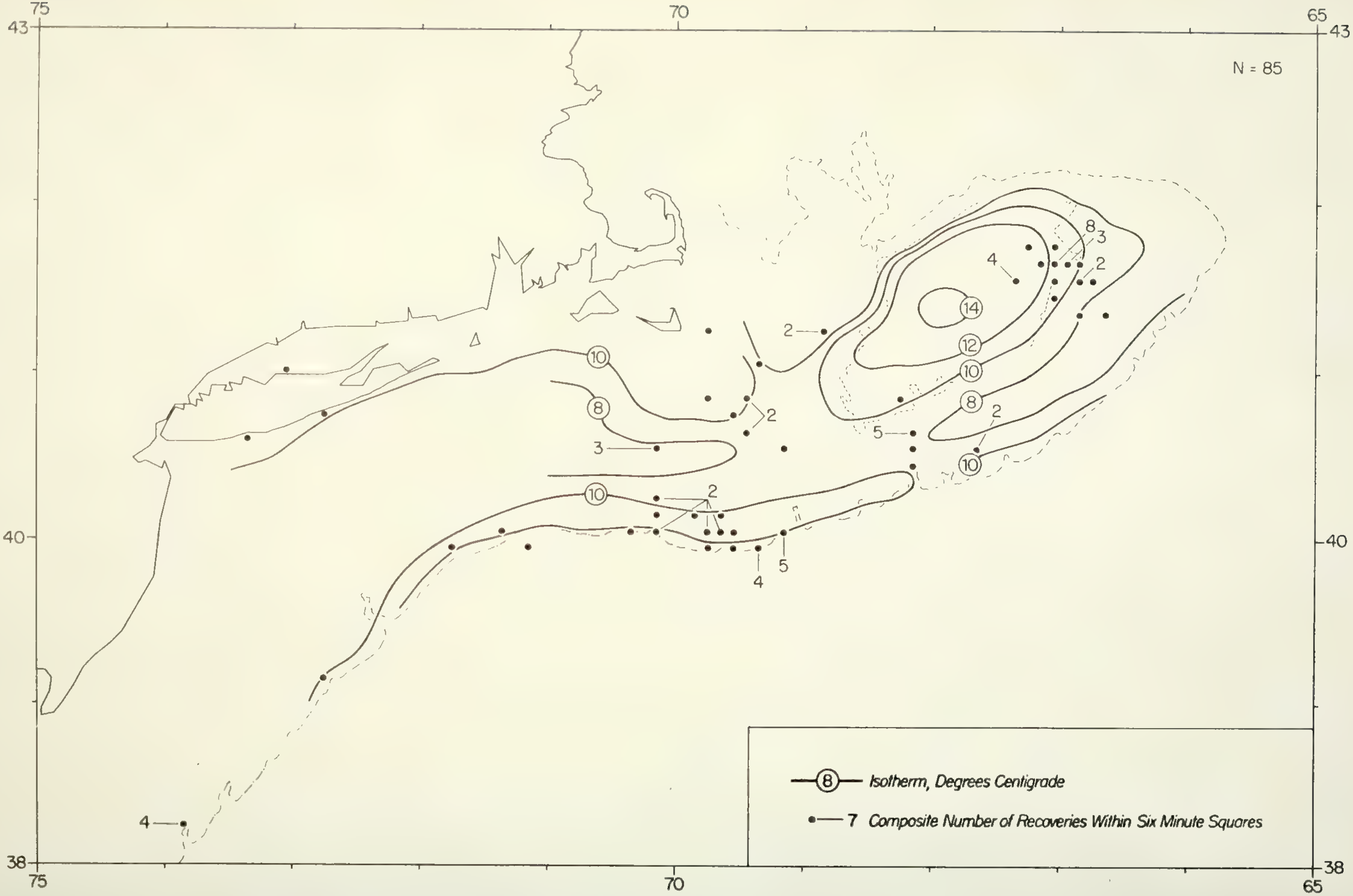

75
70
65
43
40
38
N = 85
14
12
10
8
2
3
4
5
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 40.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—July.

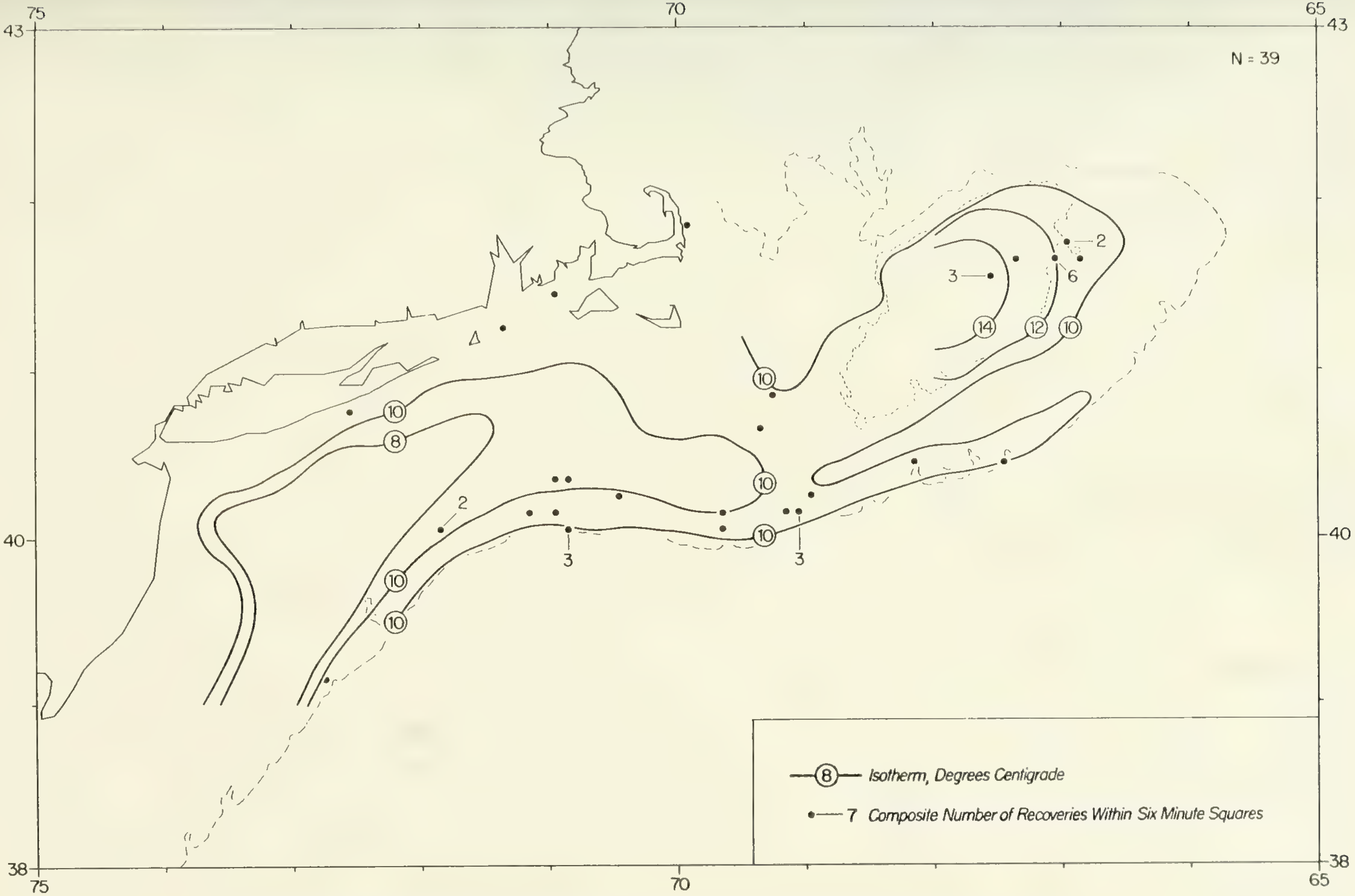

75
70
65
43
40
38
N = 39
2
6
3
14
12
10
10
10
10
10
8
2
3
3
10
10
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 41.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—August.

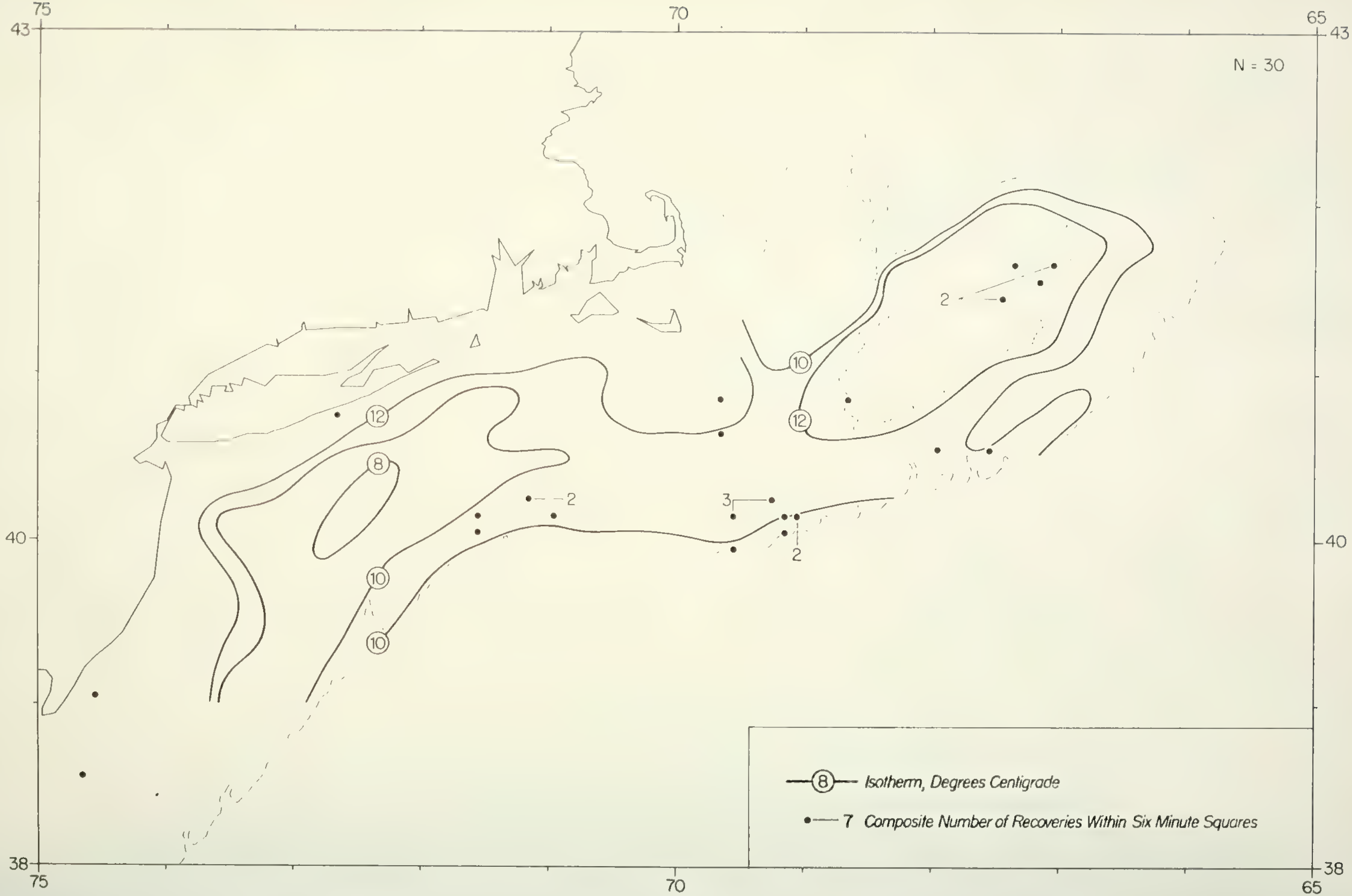

75
70
65
43
40
38
N = 30
(12)
(10)
(8)
2
3
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 42.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—September.

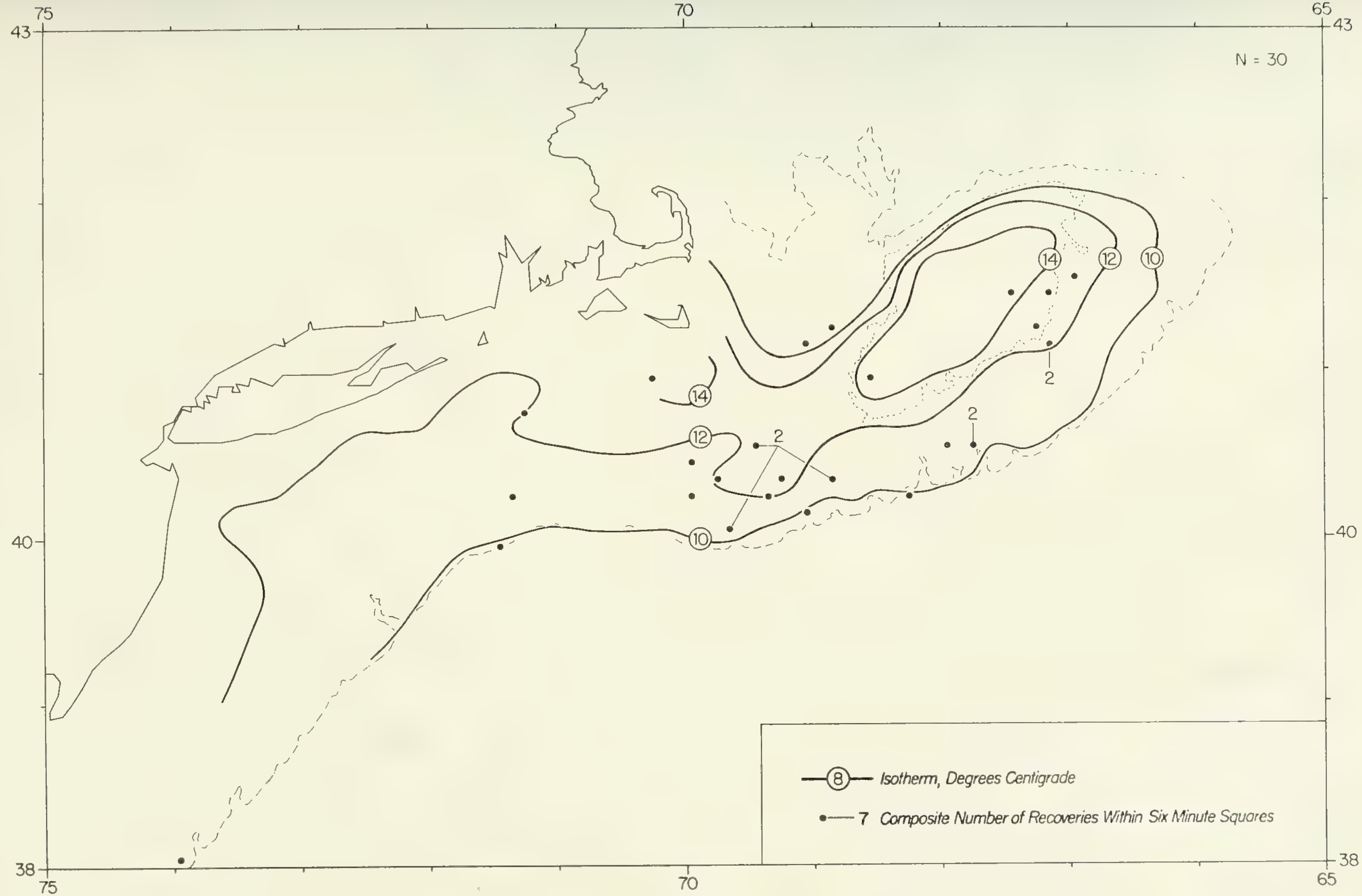

75
70
65
43
43
N = 30
14
12
10
14
12
10
2
2
2
40
40
38
38
75
70
65
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 43.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—October.

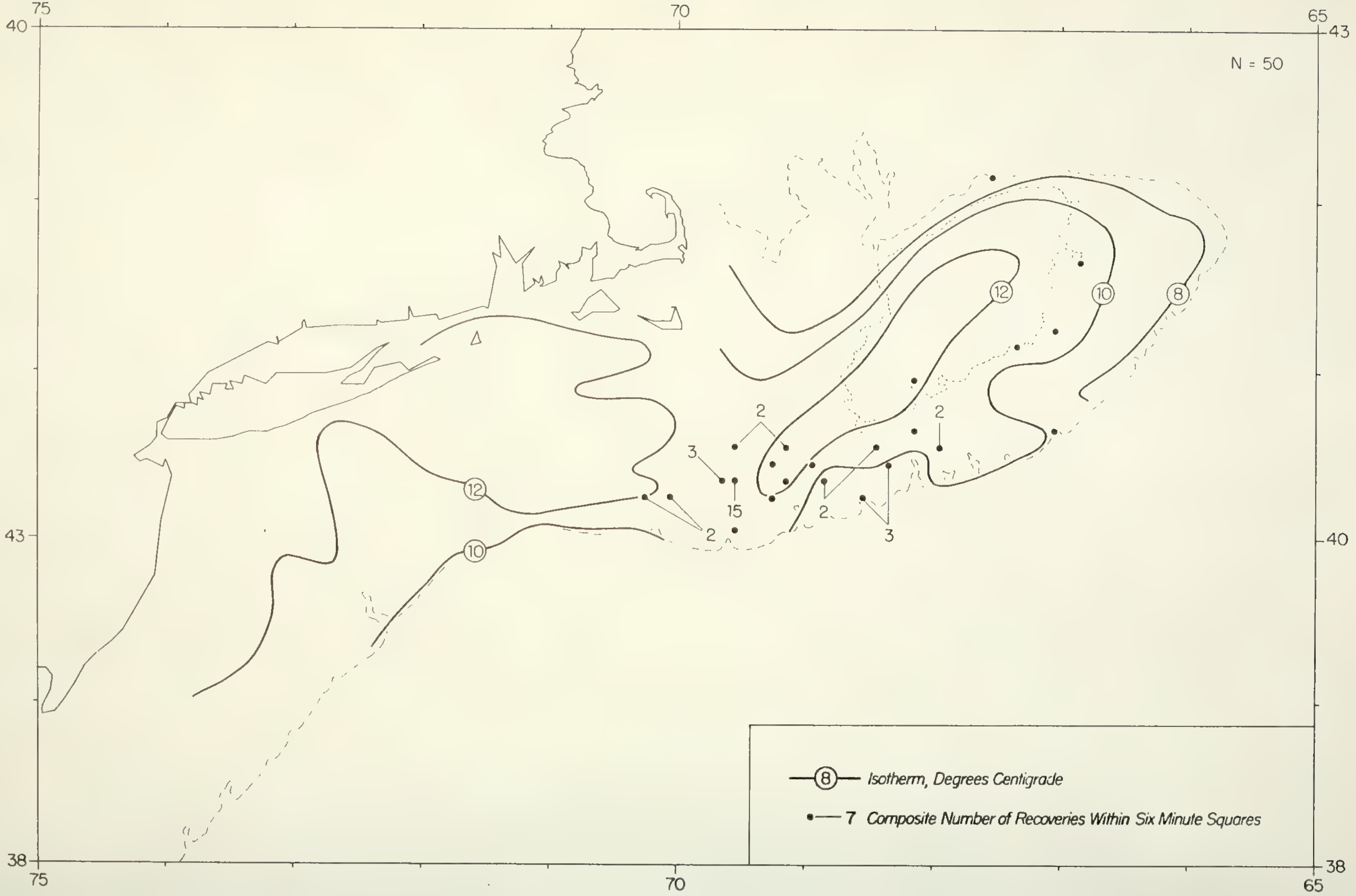

75
70
65
40
43
43
40
38
38
75
70
65
N = 50
8
10
12
12
10
2
2
3
15
2
2
3
2
3
Isotherm, Degrees Centigrade
7 Composite Number of Recoveries Within Six Minute Squares

Figure 44.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—November.

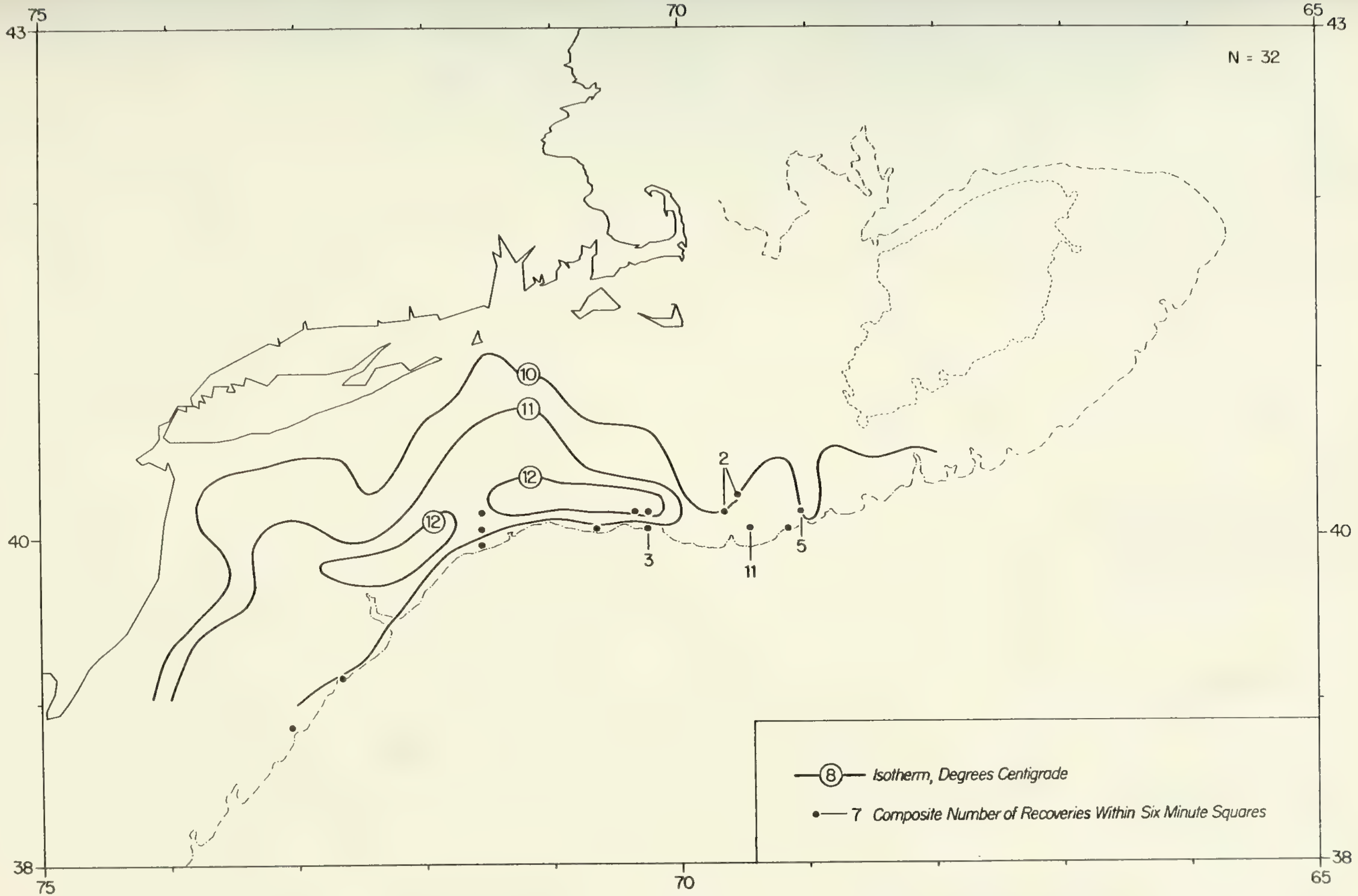

75
70
65
43
43
N = 32
40
40
38
38
75
70
65
10
11
12
12
2
3
11
5
8
Isotherm, Degrees Centigrade
7
Composite Number of Recoveries Within Six Minute Squares

Figure 45.—Composite of recoveries by months by 6-minute squares with mean monthly bottom temperature—December.

that of 758M followed by an equal, but nonreciprocal return leg leading back to the point of capture west of Block Canyon; we believe that this hypothetical kind of two-stage movement could account for many of the apparently directed easterly or westerly movements.

Only four of the recaptures qualify as migrants; all were recaptured in significantly shoaler water with three of the four effecting large-scale movements approximating 1 mile (1.85 km) per day while at large. Each of the tracks show optimal or near optimal directionality relative to the shoaling objective. Calculated bearing, ground speed, and depth change of these migrants are as follows:

Return no.	Bearing	Ground speed mi/day	Ground speed km/day	Depth change fathoms	Depth change meters
721F	004°	1.0	1.9	+38	+70
738F	004°	0.9	1.7	+30	+55
779F	018°	0.5	0.9	+35	+64
758M	322°	1.0	1.9	+55	+101

SUMMARY OF DEFINED MOVEMENTS

It should be recalled that this report deals with 945 recaptured lobsters among which 584 (62%) of the total were reported by specific location and hence classifiable according to the scheme outlined in the section on migration versus dispersion. According to the criteria laid down, 117 recaptures have been defined as migrants, 15 as nonmigrants, 147 as residual nonmigrants, and 297 as indeterminates, thus yielding a total of 576 defined movements. The discrepancy between the total of 584 located recaptures and 576 defined movements is due to the fact that eight of the located recaptures were reported without a date of recapture and hence could not be classified.

Among the 117 defined migrants, 74 (63%) effected net shoalward movements of 10 fathoms (18.3 m) or more beyond the release point (Table 2). Although these tracks have been depicted in preceding figures as elements of the overall recovery patterns of their respective release group, it is instructive to isolate them from their original cohorts and examine them collectively. The intent of Figures 30-32 is to show more clearly the variability of performance of the migrants which conform with our hypothesis of vernal shoalward migration while eliminating the confounding effects of other kinds of movements.

The ratio of these conforming (shoaling) migrants to the sum total of defined movements is 74:576. This grouping permits the inference from these tag returns that some 13% of the population at large annually engages in seasonal shoalward migration to a greater or lesser degree.

It is important to note that 297 of the 576 classified movements fall in the indeterminate category. This group constitutes 51% of the classified movements and includes a significant number of dispersions which, while failing to meet the migrant criteria because of the 120-day time constraint, may be subjectively interpreted as migrants on the basis of relative dislocation from the continental margin and month of recapture.

In order to give fuller consideration to these movements, and to assess their additive effect on the previously derived estimate of 13% participation in annual shoalward migration, we have selected and redefined as probable migrants those indeterminates whose recapture locations were at least 50 miles (92.7 km) from original release locality and at least 50 miles (92.7 km) from the nearest margin of the continental shelf. These highly restrictive criteria admit only 22 additional entries (Table 2) to the asserted list of conforming (shoaling) migrants and raises the theoretical ratio of shoalward migrations to 17%. We have assumed that the shoalward excursions of these probable migrants commenced in springtime from the shelf margin in the vicinity of first capture or, alternatively, from some other point on the shelf margin no less than 50 miles (92.7 km) from point of recapture. These restrictions effectively exclude a considerable number of other indeterminates of only slightly lesser performance. If we assume that 13% of the indeterminates, or 39 lobsters, demonstrated vernal shoaling, as was the estimate from the defined migrants, the revised estimate of shoalward migration would be 20% (74 + 39 = 113, or 20% of 576). We can conclude from this review and reassessment of movements that at least 17-20% of the tagged population engaged in seasonally directed shoalward migration, that some 25% remained more or less localized (nonmigrants), and that the balance of classified movements (indeterminates) might, by more definitive criteria, be assignable to one or the other of the first two categories. We believe that the 17-20% estimate of shoalward migration is highly conservative. The major impediment to correct allocation of the movements observed is our unsatisfactory knowledge of 1) homing tendencies and 2) the realistic limits on the radius of dispersion of localized movements in any given year. Until these issues are resolved by further experimentation (sonic tagging with periodic tracking), we have no basis for classification other than the partly arbitrary system we have used. We believe, nevertheless, that the deductive process used is substantially valid and provides an acceptable interpretation of the seasonal movements of lobsters comprising the offshore stock. The following sections on the monthly distribution of recaptures in relation to depth and temperature further substantiates the arguments advanced heretofore.

DEPTH DISTRIBUTION AT RECAPTURE

Analysis of the depth distribution of recaptured lobsters by month of capture shows a pronounced cyclical pattern of shoaling during the shelf warming period followed by retreat to the shelf margin and slope in winter months. These trends are summarized in Figure 33 which shows mean depth at recapture by quarterly periods over the 4-yr period 1968-72.

Inspection of third quarter (July, August, September) averages shows relatively little deviation from the 4-yr mean of 50 fathoms (91.4 m); similarly, fourth quarter

Table 2.—Recapture data for 74 shoalward migrating lobsters demonstrating shoaling of 10 fathoms (18.3 m) or more and 22 probable migrants whose recapture location was at least 50 nautical miles (92.7 km) from release and at least 50 miles from nearest margin of continental shelf.

Figures 30-32 vector no.	Return no. and composite station no.	Nautical miles	Days at large	Average speed (mi/day)	Depth change (fathoms)
1	3F-3	102	29	3.5	60
2	29F-3	77	118	0.6	75
3	4F-5	11	36	0.3	34
4	26F-5	38	37	1.0	18
5	27F-5	38	37	1.0	20
6	28F-5	56	50	1.1	78
7	10F-6	24	33	0.7	42
8	18F-6	18	49	0.4	29
9	19F-6	18	49	0.4	29
10	20M-6	18	49	0.4	29
11	8M-7	72	39	1.8	37
12	41F-10	20	60	0.3	10
13	25F-13	75	28	2.7	38
14	221F-18	12	54	0.2	10
15	240F-18	66	32	2.1	36
16	249F-18	186	71	2.6	68
17	254F-18	41	71	0.6	42
18	263F-18	76	80	0.9	50
19	266M-18	21	85	0.2	15
20	311M-18	39	106	0.4	45
21	184F-19	15	40	0.4	10
22	191F-19	14	43	0.3	15
23	255F-19	45	70	0.6	45
24	294F-19	118	107	1.1	47
25	654F-19	47	41	1.1	32
26	190M-19	14	43	0.3	15
27	194M-19	17	42	0.4	10
28	246M-19	51	67	0.8	48
29	317M-19	125	86	1.4	38
30	244F-20	27	60	0.4	16
31	247F-20	18	62	0.3	11
32	252F-20	32	66	0.5	16
33	259F-20	47	70	0.7	23
34	276F-20	41	79	0.5	18
35	277F-20	41	79	0.5	18
36	306F-20	54	100	0.5	22
37	314F-20	45	81	0.5	23
38	315F-20	50	82	0.6	23
39	200M-20	35	43	0.8	13
40	285M-20	48	94	0.5	20
41	262F-21	76	44	1.7	24
42	236F-22	33	20	1.6	17
43	238F-22	32	21	1.5	18
44	251F-22	32	32	1.0	18
45	260F-22	37	38	1.0	25
46	284F-22	32	60	0.5	17
47	287F-22	38	59	0.6	21
48	288F-22	38	59	0.6	22
49	293F-22	38	60	0.6	14
50	307F-22	48	72	0.7	22
51	308F-22	48	72	0.7	22
52	309F-22	48	72	0.7	22
53	316F-22	41	48	0.9	25
54	336F-22	42	89	0.5	25
55	337F-22	42	89	0.5	25
56	339F-22	44	86	0.5	20
57	222M-22	22	23	0.9	14
58	242M-22	35	25	1.4	12
59	243M-22	40	28	1.4	20
60	248M-22	41	31	1.3	24
61	258M-22	32	37	0.9	23
62	261M-22	35	41	0.8	19
63	278M-22	30	45	0.7	18
64	310M-22	38	67	0.6	20
65	341M-22	32	89	0.3	18
66	342M-22	32	89	0.3	18
67	576F-23	52	48	1.1	59
68	584F-23	39	84	0.5	51
69	562M-23	80	16	5.0	52
70	564M-23	83	15	5.5	50
71	721F-29	50	49	1.0	38
72	738F-29	50	53	0.9	30
73	779F-29	39	79	0.5	35
74	758M-29	111	108	1.0	55
75	544F-7	58	771		
76	335F-13	56	465		
77	347F-14	65	365		
78	348F-14	62	365		
79	349F-14	59	365		
80	350F-14	59	365		
81	269M-14	65	392		
82	357F-17	58	353		
83	768F-17	76	1,010		
84	937M-17	132	973		
85	355F-18	70	166		
86	720M-18	110	761		
87	610F-19	66	443		
88	577M-19	78	522		
89	578F-20	87	519		
90	575F-22	155	431		
91	770F-22	103	750		
92	767M-23	62	389		
93	769M-23	60	377		
94	771F-23	54	361		
95	740F-27	52	227		
96	917F-27	71	230		

averages are in good agreement with the 4-yr mean of 66 fathoms (121 m). In contrast, the first quarter averages show an almost straight-line cline ranging from 197 fathoms (360 m) in 1969 to 127 fathoms (232 m) in 1972; the implication of this trend is not clear because of the relatively small numbers and large range of observations from which these means were derived. If, however, the trend is real, it suggests that slope waters became progressively warmer over the 4-yr period to the degree that optimal overwintering conditions (discussed below under Average Monthly Bottom Temperatures) were met at progressively shoaler levels. The sum of deviations of second quarter means from the 4-yr averages are almost as great as those of the first quarter; here, however, the major source of deviation stems from a disproportionate number of deep-running recaptures taken in April 1970.

Despite the shortcomings of the data, the clearly cyclical nature of seasonal depth change seems, independent of net track analyses, adequate evidence of the tendency of offshore lobsters to optimize their year-round temperature regime. The consequences of this behavior are manifold in that metabolic rates and related life processes are doubtless accelerated relative to the coastal zone populations which tend to remain highly localized and hence subject to wider seasonal extremes and significantly lower mean annual temperature.

AVERAGE MONTHLY BOTTOM TEMPERATURES

The distribution of recaptured tagged lobsters by month and grouped by 6-minute squares against average bottom water temperatures (°C) from Colton and Stoddard (1973) are presented in Figures 34-45. Bottom isotherms are plotted from data collected during the period 1940-66. Only recaptures whose month and location of recapture are known ($N = 584$) are plotted.

Relating lobster distribution to average bottom water temperatures, it is apparent that the offshore lobster population generally maintains itself within a temperature regime of 8°-14°C. The two apparent exceptions to this generalization, evident in Figures 36 (March) and 37 (April), are predictable. Bottom isotherms represent average temperature conditions for a 26-yr period, and the temperature conditions for a given month vary considerably from year to year and within a given month (Colton and Stoddard 1973; and Chamberlin[2]).

During the first quarterly period, January through March, offshore lobsters are distributed along the outer continental shelf and upper slope (Figs. 34-36). Bottom water temperatures during this period ranged from 8° to 12°C (Colton and Stoddard 1973; Chamberlin[2]). In contrast, the inshore, shallow-water lobster populations are in a state of reduced activity in coastal waters of 0°-4°C (Cooper et al. 1975).

During the second quarterly period, April through June, the onset of shoalward migration has begun, occurring first (April and May) in the western half of the shelf (Figs. 37, 38) and next (June) in the eastern half of the shelf (Fig. 39). Bottom water temperatures in the latter half of May along southern Long Island, Block Island Sound, and Buzzards Bay are 8°C and warmer (Colton and Stoddard 1973). An intensive fishery for lobsters occurs along southern Long Island from late May through mid-July, directed primarily toward the onshore migrants emanating from Hudson to Veatch Canyon (Cooper and Uzmann, unpubl. studies). Lobster migrations into the southern Long Island coastal waters are evident from Figures 6, 15, and 16.

Figures 40-43 (July-October) demonstrate that the offshore lobster population is widely distributed over the southern New England continental shelf, including the shoal waters of Georges Bank and the coastal waters of Long Island, Rhode Island, southern Massachusetts, and Cape Cod. Bottom water temperatures in areas of apparent lobster abundance during July-September are 8°-14°C.

The return migration to the outer shelf-upper slope waters probably begins in August (Fig. 41) and continues through September, October, and November (Figs. 42-44). Migration to deep water first occurs in the western half of the shelf and then in the eastern half.

During the first month (October) of the last quarter (October-December) there are still some lobsters distributed over the shoals of Georges Bank and immediately south of Nantucket Island (Fig. 43) with bottom water temperatures of 10°-14°C. By December the offshore lobster population is again distributed along the outer continental shelf and upper slope waters (Fig. 45) where bottom temperatures are 8°-12°C.

CONCLUSIONS

The distribution of tag returns from a 4-yr tagging and recapture study has demonstrated that at least 20% of the offshore lobster population moves into shoal water in the spring and summer and returns to the outer shelf and upper slope by early winter. This migratory behavior appears to be motivated by temperature, as the seasonal distribution of tagged lobsters according to depth is well correlated with bottom temperature. The extensive seasonal migrations undertaken by offshore lobsters contrast sharply with the localized movements of coastal stocks. This apparent difference may be partially explained by the very high exploitation rate inshore such that most lobsters of recruit size are quickly harvested within the bounds of locally intensive fisheries.

Whether the offshore stocks are genetically distinct from the coastal stocks has not been established, but it is evident that the shelf edge and upper slope is a permanent habitat from which small- and large-scale excursions are made with seasonal regularity. We believe that the continental slope habitat lacks sufficiently high temperatures during the summer to promote extrusion of eggs, molting, and subsequent mating, and that the deficiency is compensated by seasonal shoalward migration to warmer water. In situ observations of offshore lobsters from the research submersible *Nekton Gamma*[3] at Corsair, Lydonia, Oceanographer, Hydrographer, and Veatch canyons during June-July of 1973 and 1974 substantiate this belief. Evidence of lobster molting (shed exoskeleton) was observed only at depths shoaler than 100-110 fathoms (183-201 m), whereas lobsters were distributed to depths of at least 170 fathoms (311 m).

The magnitude of variation in depth at recapture by month suggests that the migration toward shoal water is not a total population response, nor is it likely a well-coordinated one. We hypothesize that some lobsters migrate early, some late, and some not at all. Superimposed upon these variations in migratory behavior is an apparent tendency of some lobsters to move laterally east or west along the outer shelf and upper slope. Hence, the concept of discrete canyon populations is unlikely.

SUMMARY

1. This report has presented the results of an offshore lobster tag and recapture study to define the seasonal

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[2] Chamberlin, J. L. Bottom temperatures on the continental shelf and slope south of New England during 1974. *In* J. Goulet (editor), Environment of the United States living marine resources—1974, p. 18-1 to 18-7, figs. 18.1-18.6 (NMFS unpubl. manuscr.)

[3] Research submersible operations provided by NOAA's Manned Undersea Science and Technology Office.

migratory behavior and population distribution of the offshore lobster population ranging from Corsair Canyon and the southeastern extremes of Georges Bank to Baltimore Canyon off the coast of Virginia. A total of 7,326 offshore lobsters were tagged and released at 52 localities, grouped into 29 composite release stations to effect a logical pooling of release and recapture information and expedite the plotting and evaluation of the data.

2. Cooper and Uzmann (1971) hypothesized, on the basis of a described time-temperature relationship, that the nature of the offshore lobster migration phenomenon was a vernal shoalward movement to warmer water with subsequent return to the outer edge of the shelf and upper slope with the onset of fall and winter. In this report we attempt to elicit qualitative and quantitative aspects of individual movements from groupings of individuals referenced to release locality, point of recapture, and time at large.
3. Among the 945 recaptured lobsters, 584 (62%) were reported by specific location, 183 (19%) by generalized location, and 178 (19%) without location information of any kind. A classification scheme is presented which distinguishes between directed migrants and those whose net movements over time are inconsequential or not clearly directional. We have defined a migrant as an individual that has moved a distance of 10 miles or more in 10-120 days from time of release to time of recapture. A total of 117 (20% of 584) lobsters meet our requirements of defined migrants.
4. Between 17 and 20% of the 576 recaptured lobsters whose net movements were definable (classified movements) demonstrated seasonal shoalward migration. The highly restrictive criteria used herein for defining shoalward migrants have probably excluded a considerable number of other recaptures that had, in fact, migrated into shoaler water. Therefore, the estimate of 17-20% annual shoalward migration is probably an underestimate. Approximately 25% of the tagged population remained localized (nonmigrants) and some portion of the remaining 55-58% of the classified movements (indeterminates) might, through more definitive criteria of classification, be assignable as shoalward migrants or nonmigrants.
5. Forty-three (37%) of the defined migrants (117) moved laterally along the outer edge of the continental shelf. There is no apparent reason for this lateral movement easterly or westerly during spring and summer. Discrete submarine canyon populations seem unlikely in view of these lateral movements. In contrast, 63% of the defined migrants moved into shoal water.
6. Analysis of the depth distribution of recaptured lobsters by month of capture shows a pronounced cyclical pattern of shoaling during March-August followed by a return to the shelf margin and upper slope during October-December. These cyclical changes in depth by season, independent of net track analyses, provides additional support for the hypothesis of Cooper and Uzmann (1971) of inshore-offshore movements of the offshore lobster population.
7. The distribution of recaptured lobsters by month of capture and mean bottom water temperature demonstrates that the offshore lobster population, through random and/or directed movements, maintains itself within a temperature regime of 8°-14°C.

ACKNOWLEDGMENTS

We thank National Marine Fisheries Service port agents John V. Mahoney, Churchill T. Smith, Fred C. Blossom, Paul P. Swain, and Dennis E. Main for invaluable assistance in locating, collecting, and reporting tagged lobsters taken by the commercial fishing fleet. Special thanks are due to John P. Laird, National Marine Fisheries Service, Woods Hole, for assistance with programming and execution of computer and plotter runs. The laboratory draftsmen, John R. Lamont and James A. Rollins, have our deep appreciation for their patient craftsmanship with our many requirements. Likewise, we sincerely thank Gwendolyn L. Kelley, staff typist, and Gareth W. Coffin, staff photographer, for their essential services in the final production of this report.

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APPENDIX TABLES

Key to Column Headings

RET - Return number plus F (female) or M (male) suffix on column entries
CS - Composite station number
OS - Original station number
MO - Month of recapture
RLAT - Release latitude
RLON - Release longitude
CLAT - Recapture latitude
CLON - Recapture longitude
DATL - Days at large
MIL - Miles (nautical)
CL1- Carapace length at release
CL2- Carapace length at recapture
EC - External egg code; first digit is egg code at release, second digit is egg code at recapture:
  1 - no eggs
  2 - new eggs
  3 - mature eggs
  4 - unreported
  5 - eggs, stage unreported

Appendix Table 1

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
128F	1	1	5	4017	6803			421		118	118	11
723M	1	2	6	4017	6803			1191		185	212	
856M	1	1	11	4017	6803	4031	6758	1342	13	119		

Appendix Table 2

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
13M	2	4	6	3959	6936	4009	6951	67	16	80	80	
17M	2	4	6	3959	6936	4002	6936	76	3	102	102	
466M	2	4	4	3959	6936	VEAT		741		97	135	

Appendix Table 3

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
3F	3	5	5	3931	7213	4105	7121	29	102	96		14
11F	3	5	5	3931	7213	3938	7225	26	13	78	78	11
23F	3	5	5	3931	7213	3955	7145	6	33	90	90	11
29F	3	5	8	3931	7213	4047	7235	118	77	94	94	11
345F	3	5	8	3931	7213	3907	7243	470	34	70		14
346F	3	5	7	3931	7213	3907	7243	460	34	72		14
660F	3	5	2	3931	7213			1024		79	104	11
2M	3	5	5	3931	7213	3935	7215	15	5	74	74	
38M	3	5	8	3931	7213	HUDS		125		73		

Appendix Table 4

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
87F	4	6	1	4005	7109	4000	7106	254	6	85	99	11
462F	4	6	4	4005	7109			344		92		55
875F	4	6	12	4005	7109			1326		69	88	44
7M	4	6	6	4005	7109	4009	7112	43	5	103		
12M	4	6	5	4005	7109	4005	7122	7	10	79	79	
173M	4	6	6	4005	7109	4003	6938	405	71	100		
409M	4	6	12	4005	7109			597		73	108	

Appendix Table 5

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
4F	5	8	6	4004	7027	4010	7016	36	11	87		14
5F	5	8	5	4004	7027	4009	7026	31	6	103	103	55
6F	5	7	5	4005	7027	4013	7023	27	8	80	80	11
14F	5	7	6	4005	7027	4009	7026	34	5	81	81	11
15F	5	7	6	4005	7027	4004	7035	43	7	78	78	11
21F	5	8	7	4004	7027			83		82		11
26F	5	8	6	4004	7027	4001	6938	36	38	100	100	12
27F	5	7	6	4005	7027	4001	6938	37	38	107	107	55
28F	5	7	6	4005	7027	4045	6938	50	56	124	124	55
36F	5	7	8	4005	7027			93		67		14
37F	5	8	8	4004	7027			92		169		14
43F	5	7	9	4005	7027	4006	6930	127	44	93		14
44F	5	7		4005	7027					94		14
53F	5	7	11	4005	7027	4019	6849	191	76	111		14
58F	5	8	11	4004	7027	4015	7002	199	23	111		14
60F	5	7	12	4005	7027	4011	7016	216	10	110		14
82F	5	8	1	4004	7027	3957	7013	274	14	89	103	12
377F	5	8	11	4004	7027	4016	7017	564	15	73		14
456F	5	7	2	4005	7027			657		87	100	11
487F	5	7	5	4005	7027	4002	6907	735	61	99	112	11
498F	5	8	5	4004	7027	VEAT		740		79		14
551F	5	7	6	4005	7027	4000	7039	774	10	88		14
16M	5	8	6	4004	7027	4004	7035	42	7	76	76	
40M	5	8		4004	7027					99	99	
68M	5	7	12	4005	7027	4003	7017	236	7	80	96	
76M	5	8	1	4004	7027	3959	7054	257	22	77	77	
398M	5	8	11	4004	7027	4020	6934	569	44	93	108	
521M	5	7	5	4005	7027			747		72		
535M	5	8	6	4004	7027			767		98	116	

Appendix Table 6

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
9F	6	11	6	3957	6953	3958	6918	36	27	79	79	11
10F	6	9	6	3958	6959	4003	6929	33	24	88		11
18F	6	9	6	3958	6959	4003	6936	49	18	84	84	11
19F	6	9	6	3958	6959	4003	6936	49	18	99	99	11
57F	6	9	11	3958	6959	4018	6849	197	57	123		14
67F	6	9	12	3958	6959	4003	7017	234	15	119	119	11
71F	6	11	1	3957	6953	4000	7008	259	10	92	92	12
73F	6	9	1	3958	6959	4002	6906	259	41	113	127	31
86F	6	9	1	3958	6959	3957	7054	252	42	102	102	31
91F	6	11	1	3957	6953	4013	6832	266	63	83	83	12
324F	6	9	9	3958	6959	4006	7130	496	71	84		14
436F	6	9	11	3958	6959	VEAT		563		114		31
1M	6	9	5	3958	6959	4000	7118	12	62	101	101	
20M	6	9	6	3958	6959	4003	6936	49	18	86	86	
50M	6	9	11	3958	6959	4016	7002	187	19	83	99	
70M	6	9	1	3958	6959	4000	6937	262	17	89		
85M	6	9	1	3958	6959	4001	7012	274	11	104	104	
253M	6	11	7	3957	6953	4040	6926	435	47	96	115	
279M	6	11	7	3957	6953			425		74		
433M	6	11	1	3957	6953	4006	6840	616	58	87	102	
633M	6	9	10	3958	6959	4015	6955	896	18	67		
656M	6	9	2	3958	6959			1020		99		

Appendix Table 7

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
74F	7	10	1	3956	6942	3955	6940	256	1	100	114	31
84F	7	10	1	3956	6942	4001	7012	272	23	83	98	11
104F	7	10	4	3956	6942	4000	6912	336	23	100	100	11
112F	7	10	4	3956	6942	3958	6914	354	21	132	132	11
438F	7	10	1	3956	6942			624		109	127	11
495F	7	10	5	3956	6942	4009	6903	739	31	96	109	11
544F	7	10	6	3956	6942	4054	6941	771	58	90	103	11
8M	7	10	6	3956	6942	4009	7115	39	72	111	111	
437M	7	10	1	3956	6942	4000	6937	626	5	71	101	
538M	7	10	5	3956	6942			753		86		

Appendix Table 8

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
39F	8	12	8	3959	7003	HUDS		74		84		14
156M	8	12	5	3959	7003	4031	6740	350	114	91		
245M	8	12		3959	7003					100	120	
546M	8	12	6	3959	7003	3957	6929	734	26	111	130	

Appendix Table 9

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
47F	9	13	10	4003	7018	4015	6923	132	43	89	104	11
62F	9	13	12	4003	7018	VEAT		178		88	101	14
69F	9	13	1	4003	7018	3957	7044	204	22	83		14
105F	9	13	4	4003	7018	4002	7028	298	8	93	93	11
381F	9	13	11	4003	7018	4025	6915	533	51	86	99	11
413F	9	13	12	4003	7018			545		75	100	11
429F	9	13	1	4003	7018			561		94	108	11
439F	9	13	1	4003	7018	4000	7034	592	13	76	102	11
693F	9	13	6	4003	7018	3958	6926	1087	40	76		14
713F	9	13	2	4003	7018	3956	6955	975	19	72		14
908F	9	13	6	4003	7018	3955	6935	1453	34	76	100	44
66M	9	13	12	4003	7018	4003	7017	189	2	140	140	
389M	9	13	11	4003	7018	4020	6934	533	37	74	104	
406M	9	13	12	4003	7018	VEAT		547		87	103	
420M	9	13	12	4003	7018			548		72		
453M	9	13	2	4003	7018	4001	6908	605	54	73		
457M	9	13	2	4003	7018			610		91	130	
515M	9	13	5	4003	7018	4001	7054	704	28	82		
946M	9	13	3	4003	7018	4035	6755	1549	118	101	165	

Appendix Table 10

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
34F	10	14	7	4013	7031	4013	7010	39	16	76	76	11
41F	10	14	8	4013	7031	4022	7052	60	20	76		14
30M	10	14	8	4013	7031	4013	7024	46	6	69		

Appendix Table 11

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
31F	11	15	7	4013	7015	4017	7007	30	7	71		14
83F	11	15	1	4013	7015	4001	7012	227	12	87	99	12
90F	11	15	2	4013	7015	3959	7012	231	14	72	83	11
499F	11	15	5	4013	7015	4006	6839	695	74	93	107	11
553F	11	15	6	4013	7015	4011	6849	727	65	98		14
94M	11	15	2	4013	7015	3955	6933	253	37	117	117	

Appendix Table 12

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
196F	12	16	6	4012	7114	3955	7154	358	35	97	97	11
48M	12	16	10	4012	7114	4012	7119	120	4	113	113	
72M	12	16	1	4012	7114	4000	7008	214	52	102	120	

Appendix Table 13

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
22F	13	17	7	4004	7150	4000	7122	14	23	91		14
24F	13	17		4004	7150					91	91	55
25F	13	17	7	4004	7150	4037	7318	28	75	97	97	55
32F	13	19	8	4005	7143	4000	7153	56	9	78	90	11
61F	13	19	12	4005	7143	4009	7022	174	63	88	103	14
63F	13	18	12	4006	7148	3908	7241	178	70	79	103	11
64F	13	18	12	4006	7148	3848	7302	183	96	99	99	11
65F	13	18	12	4006	7148	4001	7039	182	52	79	93	11
78F	13	19		4005	7143					83		14
81F	13	19	1	4005	7143	3957	7013	224	71	88	88	11
99F	13	17	3	4004	7150			259		95	109	31
115F	13	19		4005	7143					68		14
164F	13	19	5	4005	7143			345		92	107	11
267F	13	18	7	4006	7148			397		98		51
270F	13	19	6	4005	7143	3956	7145	375	9	85	85	11
297F	13	17	6	4004	7150			350		87		14
335F	13	18	9	4006	7148	4045	7240	465	56	92	105	11
353F	13	19	10	4005	7143	4044	7116	484	45	65	83	11
407F	13	17	12	4004	7150	VEAT		544		87	101	31
486F	13	19	5	4005	7143	4007	6936	681	98	90	102	11
615F	13	19	8	4005	7143			792		85	98	11
618F	13	18	9	4006	7148			824		89	102	11
772F	13	17	7	4004	7150	VEAT		1121		79	109	44
879F	13	17	11	4004	7150	4005	6935	1228	104	97		54
905F	13	18	3	4006	7148	3908	7243	1360	72	88		44
42M	13	17	8	4004	7150	4022	7054	58	47	72		
59M	13	17	11	4004	7150	4017	7012	158	76	86	103	
92M	13	17	1	4004	7150	VEAT		227		89		
95M	13	17	2	4004	7150	4012	7119	235	25	87		
106M	13	17	4	4004	7150	3950	7149	302	14	97		
108M	13	17	2	4004	7150	4007	7123	238	21	94		
175M	13	18	6	4006	7148	3957	7157	353	11	85	97	
250M	13	18	7	4006	7148			381		86		
268M	13	18	7	4006	7148			378		107		
325M	13	17	8	4004	7150			434		103		
472M	13	17	4	4004	7150			655		94	132	
585M	13	18	9	4006	7148	4007	7058	816	39	98	137	
649M	13	17	1	4004	7150	4008	7132	941	15	98	137	
742M	13	18	10	4006	7148			1215		75		
870M	13	18	12	4006	7148	4005	6925	1267	108	89		

Appendix Table 14

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
35F	14	21	9	4005	7138	4003	7134	79	6	82		14
49F	14	21	10	4005	7138	4023	6944	129	89	94	108	11
80F	14	20	1	4007	7138	3952	7147	224	16	89	102	11
93F	14	21	2	4005	7138	BLOC		235		77		14
96F	14	20	3	4007	7138	3910	7229	262	69	87	87	12
147F	14	20	5	4007	7138	3958	7127	341	12	79	93	11
174F	14	20	6	4007	7138					80		14
235F	14	20	7	4007	7138	4008	7006	376	71	91		15
322F	14	21	9	4005	7138	4012	7107	441	26	74		14
323F	14	20	9	4007	7138	4012	7107	441	25	95		12
330F	14	20	7	4007	7138	4010	6939	378	91	87		14
347F	14	21	5	4005	7138	4045	7243	365	65			
348F	14	21	5	4005	7138	4046	7238	365	62			
349F	14	21	5	4005	7138	4048	7230	365	59			
350F	14	21	5	4005	7138	4049	7228	365	58			
430F	14	21	1	4005	7138			556		88	101	11
446F	14	21	12	4005	7138	4004	7135	546	4	81	93	12
504F	14	21	5	4005	7138	4005	7135	689	2	82	96	13
726F	14	20	6	4007	7138	4029	6743	1077	181	91	121	14
33M	14	21	8	4005	7138	4000	7153	55	12	98	98	
79M	14	21	1	4005	7138	3941	7152	222	26	92	107	
151M	14	20	5	4007	7138	3956	7003	328	73	95		
269M	14	20	7	4007	7138	4044	7246	392	65	100	117	
422M	14	20	12	4007	7138	4009	7130	556	7	104	126	
634M	14	21	10	4005	7138	3958	7124	836	13	123		

Appendix Table 15

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
51F	15	22	11	4142	6652	4136	6648	44	7	117		14
107F	15	22	5	4142	6652	4137	6627	227	19	136		14
289F	15	22	8	4142	6652	4139	6700	321	7	86	86	11
548F	15	22	6	4142	6652	4109	6620	640	41	157		14
607F	15	22	7	4142	6652			666		151	163	11
620F	15	22	10	4142	6652	4130	6654	759	12	107	121	11
77M	15	22	1	4142	6652			132		141	141	
130M	15	22	5	4142	6652			231		142	142	
286M	15	22	8	4142	6652	4140	6705	321	10	156	156	
724M	15	22	6	4142	6652			1002		167		

Appendix Table 16

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
45F	16	23	10	4031	6837	4034	6927	20	38	98	98	11
52F	16	25	11	4029	6837	4018	6907	38	25	86		14
55F	16	26	11	4035	6842	4032	6906	55	18	85		14
98F	16	25	3	4029	6837	4004	6852	173	27	96	96	31
100F	16	26	3	4035	6842	4014	6817	171	28	105	105	11
114F	16	24	4	4030	6836			215		90	100	11
165F	16	24	6	4030	6836	4002	6933	250	52	104	104	11
176F	16	26	6	4035	6842	4008	7027	257	84	92	92	31
241F	16	24	6	4030	6836	4024	6816	250	15	103	103	11
367F	16	26	11	4035	6842			415		83	100	11
434F	16	26	12	4035	6842	HYDR		447		94		14
449F	16	23	2	4031	6837	VEAT		514		102		31
539F	16	26	5	4035	6842			231		115		14
559F	16	25	6	4029	6837	4020	6818	640	17	120		14
616F	16	26	9	4035	6842	VEAT		719		108		24
629F	16	26	10	4035	6842	HYDR		735		105	117	31
731F	16	23	6	4031	6837			981		84	110	14
732F	16	26	6	4035	6842			980		85	120	14
749F	16	26	8	4035	6842	4015	6855	1062	21	86	100	44
762F	16	25	7	4029	6837	OCEA		1034		98		44
46M	16	24	10	4030	6836	4034	6927	20	39	123	123	
54M	16	25	11	4029	6837	4032	6906	56	22	96		
75M	16	25	1	4029	6837	3959	6937	113	54	92	92	
88M	16	26	10	4035	6842	4022	6850	7	14	98		
89M	16	25	10	4029	6837	4022	6850	8	12	85		
97M	16	26	3	4035	6842	4004	6852	172	31	90	90	
101M	16	24	3	4030	6836	4005	6850	177	27	107	107	
102M	16	26	4	4035	6842	4019	6809	189	29	128	128	
103M	16	24	4	4030	6836	4019	6809	191	23	92	92	
109M	16	25	4	4029	6837	4015	7016	194	77	101		
110M	16	25	4	4029	6837	4014	6810	203	26	120	120	
113M	16	24	4	4030	6836			215		100	100	
116M	16	25	5	4029	6837	VEAT		237		137		
139M	16	24	5	4030	6836	4007	6905	237	32	79	89	
145M	16	23		4031	6837					99	99	
157M	16	26	6	4035	6842	4007	6908	248	34	109	109	
159M	16	26	6	4035	6842	4008	6845	252	26	83	83	
170M	16	25	6	4029	6837			249		116		
195M	16	26	6	4035	6842	4012	6840	269	23	131	131	
197M	16	25	6	4029	6837	4012	6840	269	17	122	122	
220M	16	25	6	4029	6837	4010	6841	272	19	93	93	
223M	16	23	6	4031	6837	4016	6829	275	15	104	104	
224M	16	24	6	4030	6836	4008	6907	275	32	109	109	
257M	16	25	7	4029	6837			290		107	107	
296M	16	25	6	4029	6837			251		86		
362M	16	25	11	4029	6837	4206	6734	411	107	76		

Appendix Table 16 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
379M	16	23	10	4031	6837	4109	6707	384	79	90		
401M	16	25	12	4029	6837	4010	6902	439	27	74	86	
473M	16	25	4	4029	6837	VEAT		557		84	99	
529M	16	24	6	4030	6836			620		80	95	
540M	16	25	5	4029	6837	4005	6915	612	38	156		
552M	16	25	6	4029	6837	4015	6845	641	16	94		
563M	16	25	7	4029	6837	4035	7009	648	70	76	96	
628M	16	25	10	4029	6837	HYDR		736		106	125	
741M	16	26	9	4035	6842	4032	6735	1077	51	126		
759M	16	25	10	4029	6837	4016	6812	1103	23	83	147	
918M	16	23	7	4031	6837	4025	6810	1380	21	117	165	
932M	16	25	8	4029	6837	4028	6725	1407	55	96	143	
933M	16	25	7	4029	6837			1381		105		

Appendix Table 17

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
131F	17	28	5	4033	6745			206		156	156	11
132F	17	27	5	4029	6739	3956	6931	201	92	132	132	11
140F	17	27	5	4029	6739	4018	6810	208	26	130	130	11
232F	17	27	6	4029	6739	4026	6733	256	5	81		11
234F	17	28	7	4033	6745	4033	6740	259	4	105	105	31
357F	17	28	10	4033	6745	4129	6728	353	58	140	140	11
481F	17	27	4	4029	6739	4026	6725	560	10	126	126	11
508F	17	28	5	4033	6745	4013	6831	577	41	100	115	11
590F	17	27		4029	6739	HYDR	WELK			100		14
591F	17	27		4029	6739	HYDR	WELK			97		14
768F	17	27	7	4029	6739	4142	6714	1010	76	117		44
784F	17	28	10	4033	6745	LYDO		1107		104		44
786F	17	27		4029	6739					119		14
940F	17	27	7	4029	6739			1367		108		54
56M	17	27	11	4029	6739	4039	6704	39	29	199		
117M	17	28	5	4033	6745	VEAT		216		121		
144M	17	27		4029	6739					109	109	
167M	17	28	6	4033	6745			229		98	98	
233M	17	28	7	4033	6745	4033	6740	259	4	116	116	
587M	17	28		4033	6745	HYDR	WELK			118		
588M	17	27		4029	6739	HYDR	WELK			74		
589M	17	28		4033	6745	HYDR	WELK			107		
744M	17	27	10	4029	6739	4033	6755	1091	12	132		
934M	17	27	7	4029	6739	4030	6810	1372	24	119		
937M	17	27	6	4029	6739	4150	6957	973	132	109		
938M	17	27	6	4029	6739	4020	6733	1338	11	114		
943M	17	28	8	4033	6745			1413		108	120	

Appendix Table 18

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
125F	18	29	5	3958	6928			15		71		14
126F	18	29	5	3958	6928			15		79		14
133F	18	29	5	3958	6928	3956	6931	4	4	103	103	55
155F	18	29	5	3958	6928			19		75		14
158F	18	30	6	3959	6925	4007	6908	31	16	72	72	11
163F	18	29		3958	6928					84	84	41
166F	18	29	6	3958	6928	4007	6908	32	18	91	91	11
180F	18	32	6	4000	6934	4007	6928	41	9	80	80	11
182F	18	29	6	3958	6928	4007	6928	43	9	77	77	11
183F	18	32	6	4000	6934	4007	6928	41	9	80	80	11
211F	18	29	6	3958	6928			56		80	80	11
221F	18	32	6	4000	6934	4002	6918	54	12	109	109	11
240F	18	32	6	4000	6934	4054	6843	32	66	101	101	11
249F	18	29	7	3958	6928	4059	7305	71	186	90		11
254F	18	30	7	3959	6925	4040	6926	71	41	121	121	31
256F	18	30	7	3959	6925			72		86	86	11
263F	18	30	7	3959	6925	4113	6946	80	76	116	116	11
271F	18	32	7	4000	6934	4004	7009	85	27	68	68	11
283F	18	32	8	4000	6934	4007	6905	102	25	71		14
291F	18	32	8	4000	6934	VEAT		91		82	82	11
295F	18	29	6	3958	6928			34		86		14
318F	18	29	8	3958	6928	4000	6937	122	7	80	93	11
319F	18	32	8	4000	6934			118		83	83	11
329F	18	29	7	3958	6928			64		92		14
340F	18	29	9	3958	6928	3957	6932	129	3	68	82	11
343F	18	32	10	4000	6934			156		87		14
355F	18	30	10	3959	6925	4058	7015	166	70	97	113	11
358F	18	29	10	3958	6928	4008	6904	181	21	74		14
361F	18	29	10	3958	6928	4003	6936	175	8	86	115	11
369F	18	29	11	3958	6928			199		76	91	11
371F	18	30	11	3959	6925			198		72	86	11
375F	18	29	11	3958	6928	4022	6941	207	24	73	89	11
376F	18	32	11	4000	6934	4022	6941	205	21	76	89	11
380F	18	32	11	4000	6934	HYDR		199		68	82	11
392F	18	32	11	4000	6934	4020	6934	212	20	75	90	11
395F	18	29	12	3958	6928	4013	6934	221	16	79	93	11
405F	18	29	12	3958	6928	VEAT		233		72		14
410F	18	29	12	3958	6928			226		97	112	31
417F	18	29	12	3958	6928			229		70		14
421F	18	32	12	4000	6934			227		69		14
427F	18	29	1	3958	6928			259		69	82	11
428F	18	32	1	4000	6934			257		83	98	11
431F	18	30	1	3959	6925			258		81	96	11
440F	18	29	1	3958	6928	4001	6908	275	15	73	86	11
445F	18	32	1	4000	6934	4003	7010	258	28	88		14
448F	18	32	2	4000	6934	VEAT		295		88	102	11
450F	18	30	1	3959	6925			274		75	88	11
454F	18	32	2	4000	6934	4001	6908	284	20	92		14
455F	18	30	2	3959	6925			290		71	85	11
461F	18	29	6	3958	6928	4000	6925	41	2	87		14

Appendix Table 18 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
468F	18	29	4	3958	6928			336		89		14
469F	18	32	4	4000	6934			334		107		14
470F	18	32	4	4000	6934			334		77		14
471F	18	32	4	4000	6934			334		72		14
476F	18	32	4	4000	6934	VEAT		340		82	82	11
477F	18	29	4	3958	6928	4028	6710	344	110	140	154	51
478F	18	32	4	4000	6934	4014	6815	352	60	74	86	11
483F	18	30	5	3959	6925	3953	6926	367	5	85	102	11
485F	18	29	5	3958	6928	4007	6936	366	11	88	100	11
494F	18	29	5	3958	6928	4009	6903	376	21	86	93	11
500F	18	29	5	3958	6928	4006	6839	377	38	88	112	11
509F	18	29	5	3958	6928	4013	6831	381	46	101		14
513F	18	32	5	4000	6934	3956	6935	383	4	60	71	11
516F	18	32	6	4000	6934	4005	6945	395	9	91	91	11
518F	18	30	6	3959	6925	3957	6925	396	2	83		14
520F	18	32	6	4000	6934	3957	6925	395	8	71		14
525F	18	32	6	4000	6934	HYDR		402		77	91	11
533F	18	32	6	4000	6934			400		61	75	11
537F	18	32	5	4000	6934			388		97	97	11
547F	18	29	6	3958	6928	4043	6938	416	45	75	90	11
560F	18	29	7	3958	6928	4004	6935	430	9	68		14
572F	18	29	6	3958	6928	VEAT		411		73		14
573F	18	30	7	3959	6925	VEAT		428		75	90	11
596F	18	29		3958	6928	HYDR	WELK			86		14
599F	18	32	8	4000	6934	4010	6908	474	22	90	104	11
603F	18	30	8	3959	6925	4004	7049	462	64	73		14
604F	18	29	8	3958	6928	4004	7049	463	62	85		14
608F	18	32	7	4000	6934			433		73	82	11
609F	18	32	6	4000	6934	3957	6934	409	3	88		14
612F	18	29	3	3958	6928	4004	6928	319	6	75		14
622F	18	29	10	3958	6928	HYDR		519		86	99	51
623F	18	30	10	3959	6925	HYDR		518		88	103	11
632F	18	32	11	4000	6934	4033	6931	548	32	59	85	11
667F	18	32	4	4000	6934	3956	6919	701	12	80	94	11
669F	18	29	3	3958	6928			688		75	92	14
676F	18	32	5	4000	6934	4012	6906	750	25	103	116	31
678F	18	32	6	4000	6934	HYDR		409		75	105	14
679F	18	32	6	4000	6934	HYDR		409		81		14
730F	18	32	6	4000	6934	4015	6845	773	41	65	91	13
800F	18	29	6	3958	6928	VEAT		42		77		14
801F	18	29	6	3958	6928	VEAT		42		82		14
803F	18	32	6	4000	6934	VEAT		40		90		14
804F	18	32	9	4000	6934	VEAT	HYDR	866		61	97	11
849F	18	30	11	3959	6925	4035	6825	921	59	85	116	11
857F	18	29	11	3958	6928	4031	6758	931	78	102		14
863F	18	30	12	3959	6925	4005	6925	950	7	81		44
894F	18	32	12	4000	6934			957		77		14
944F	18	29	9	3959	6925			1238		75	100	14

Appendix Table 18 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
122M	18	30	5	3959	6925	VEAT		19		81		
123M	18	29	5	3958	6928	VEAT		20		71		
124M	18	29	5	3958	6928	VEAT		20		83		
127M	18	29	5	3958	6928			10		94	94	
129M	18	30	5	3959	6925			9		90	90	
134M	18	29	5	3958	6928	3956	6931	4	4	87	87	
135M	18	29	5	3958	6928	3956	6931	4	4	100	100	
136M	18	29	5	3958	6928	3956	6931	4	4	70	88	
143M	18	29		3958	6928					91	91	
153M	18	30	5	3959	6925			18		81		
154M	18	29	5	3958	6928			19		73		
160M	18	29	6	3958	6928	4006	6905	36	20	102	102	
179M	18	30	6	3959	6925	4007	6928	42	9	99	99	
181M	18	29	6	3958	6928	4007	6928	43	9	75	75	
192M	18	32	6	4000	6934	4009	6933	45	9	92		
193M	18	32		4000	6934					90	90	
199M	18	29	6	3958	6928	4013	6843	52	37	153	153	
201M	18	32	6	4000	6934	4013	6843	50	41	174	174	
213M	18	30	6	3959	6925			55		82	82	
214M	18	32	6	4000	6934			54		90	90	
216M	18	32	6	4000	6934	3958	6939	54	5	161		
217M	18	29	6	3958	6928	3958	6939	56	9	130		
218M	18	29	6	3958	6928	4000	6922	58	6	88	88	
226M	18	29	6	3958	6928			60		71	82	
264M	18	29	7	3958	6928	4000	6937	81	7	101	101	
265M	18	29	7	3958	6928	4000	6937	81	7	65	88	
266M	18	29	7	3958	6928	4007	6952	85	21	89	89	
272M	18	29	7	3958	6928	3958	6923	62	3	94	94	
275M	18	30	7	3959	6925	3958	6923	62	1	85		
292M	18	29	8	3958	6928	VEAT		93		94	107	
300M	18	29	7	3958	6928	4003	6908	82	16	86		
311M	18	29	8	3958	6928	4036	6923	106	39	96	96	
312M	18	30	9	3959	6925	4008	6931	125	10	74	90	
313M	18	32	9	4000	6934	4008	6931	124	8	96	96	
326M	18	30	6	3959	6925			55		96		
327M	18	30	7	3959	6925			63		97		
328M	18	29	7	3958	6928			64		90		
333M	18	29	9	3958	6928	4014	6913	143	20	87		
359M	18	32	11	4000	6934	4113	6703	190	137	66		
360M	18	32	10	4000	6934	4003	6936	173	3	81	110	
364M	18	32	11	4000	6934	4013	6916	191	20	71	87	
368M	18	32	11	4000	6934			197		78	91	
373M	18	32	11	4000	6934			197		68	83	
374M	18	29	11	3958	6928			199		78		
382M	18	32	11	4000	6934	4020	6934	212	20	85	102	
383M	18	32	11	4000	6934	4020	6934	212	20	103	124	
387M	18	32	11	4000	6934	4020	6934	212	20	100	100	
388M	18	32	11	4000	6934	4020	6934	212	20	98	98	
390M	18	32	11	4000	6934	4020	6934	212	20	91	107	
391M	18	29	11	3958	6928	4020	6934	214	22	75	84	

Appendix Table 18 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2
393M	18	29	11	3958	6928	4020	6934	214	22	87	107
394M	18	29	12	3958	6928			219		103	
396M	18	32	12	4000	6934	4013	6934	219	13	66	78
397M	18	29	11	3958	6928	4020	6934	204	22	76	89
400M	18	32	12	4000	6934	4006	6901	222	25	64	75
402M	18	32	12	4000	6934	4009	6904	220	24	110	110
404M	18	30	12	3959	6925	4009	6904	223	19	81	99
408M	18	30	12	3959	6925			225		81	101
411M	18	32	12	4000	6934			224		79	79
412M	18	29	12	3958	6928			226		82	100
414M	18	30	12	3959	6925			225		71	87
415M	18	32	12	4000	6934			224		86	102
416M	18	29	12	3958	6928			229		77	
418M	18	30	12	3959	6925			228		91	
419M	18	32	12	4000	6934			227		126	
425M	18	32	1	4000	6934			257		79	92
426M	18	32	1	4000	6934			257		63	76
435M	18	29	12	3958	6928	HYDR		231		117	
442M	18	29	1	3958	6928			260		71	
443M	18	32	12	4000	6934	4001	6907	236	19	92	
447M	18	29	11	3958	6928			199		95	112
451M	18	30	2	3959	6925	4001	6908	285	13	74	
452M	18	30	2	3959	6925	4001	6908	285	13	81	
458M	18	29	6	3958	6928	4000	6925	41	2	100	
459M	18	32	6	4000	6934	4000	6925	39	6	112	
460M	18	30	6	3959	6925	4000	6925	40		81	
464M	18	30	4	3959	6925	VEAT		348		72	90
474M	18	32	4	4000	6934	VEAT		339		61	90
475M	18	30	4	3959	6925	VEAT		340		67	81
484M	18	32	5	4000	6934	4007	6936	364	7	92	106
488M	18	32	5	4000	6934	4002	6907	365	22	80	97
492M	18	29	5	3958	6928	VEAT		368		81	97
503M	18	29	5	3958	6928	4035	6737	374	92	120	120
514M	18	32	5	4000	6934	3956	6935	383	4	67	90
517M	18	29	6	3958	6928	4005	6945	397	14	68	92
519M	18	29	6	3958	6928	3957	6925	397	2	90	
523M	18	29	5	3958	6928			394		80	95
526M	18	32	6	4000	6934	HYDR		402		94	94
531M	18	32	6	4000	6934			400		80	95
536M	18	29	5	3958	6928			390		191	191
541M	18	29	5	3958	6928	4006	6926	371	8	85	100
542M	18	30	5	3959	6925	4006	6926	370	7	84	98
555M	18	32	6	4000	6934	4009	6905	422	23	92	110
571M	18	32	6	4000	6934	VEAT		409		91	112
582M	18	30	9	3959	6925	4009	6906	512	17	67	
583M	18	32	9	4000	6934			487		70	
605M	18	29	8	3958	6928	4004	7049	463	62	86	
613M	18	29	3	3958	6928	4004	6928	319	6	106	
617M	18	30	9	3959	6925			507		108	118
619M	18	32	10	4000	6934	4021	6915	528	25	76	112

Appendix Table 18 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
621M	18	29	10	3958	6928	HYDR		519		65	85	
625M	18	30	10	3959	6925	HYDR		518		92	110	
627M	18	32	10	4000	6934	HYDR		517		83	115	
639M	18	32	11	4000	6934			572		83	121	
647M	18	29	1	3958	6928	4010	6823	620	50	66	96	
658M	18	29	2	3958	6928			656		86		
714M	18	29	1	3958	6928	4005	6935	620	8	97		
720M	18	29	5	3958	6928	4125	7056	761	110	82		
748M	18	32	8	4000	6934	HYDR		840		73	102	
785M	18	32	11	4000	6934	HYDR		920		68	131	
799M	18	29	6	3958	6928			48		95		
802M	18	32	6	4000	6934	VEAT		40		146		
825M	18	30	4	3959	6925	HYDR		703		73	104	
852M	18	32	11	4000	6934	4040	6810	927	75	69	118	
893M	18	30		3959	6925	HYDR				105		

Appendix Table 19

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
137F	19	31	5	4004	6917	3957	6919	15	6	96	96	11
146F	19	31	5	4004	6917	4012	6907	24	11	77	77	11
152F	19	31	6	4004	6917	3958	6930	29	11	94		14
162F	19	31	6	4004	6917	VEAT		30		85	85	11
184F	19	31	6	4004	6917	4006	6935	40	15	87	87	11
191F	19	31	6	4004	6917	4009	6933	43	14	90		55
212F	19	31	6	4004	6917			52		78	78	11
219F	19	31	6	4004	6917	4000	6922	55	5	76	76	11
225F	19	31	6	4004	6917			56		80	80	11
255F	19	31	7	4004	6917	4046	6930	70	45	115	115	11
273F	19	31	7	4004	6917	3958	6923	58	7	82	82	11
274F	19	31	7	4004	6917	3958	6923	59	7	88		31
282F	19	31	8	4004	6917	4007	6905	100	10	87		14
294F	19	31	8	4004	6917	4117	7119	107	118	92	92	12
298F	19	31	7	4004	6917	4003	6908	78	7	67		14
299F	19	31	7	4004	6917	4003	6908	78	7	73		14
301F	19	31	7	4004	6917	4003	6908	78	7	75		14
302F	19	31	7	4004	6917	4003	6908	78	7	87		14
320F	19	31	9	4004	6917	4010	6905	136	11	79		14
321F	19	31	9	4004	6917	4010	6905	136	11	95		14
332F	19	31	9	4004	6917	4014	6913	139	11	68		14
334F	19	31	9	4004	6917	4049	6937	137	48	95	95	11
372F	19	31	11	4004	6917			195		68	83	11
386F	19	31	11	4004	6917	4020	6934	210	22	68	82	11
423F	19	31	1	4004	6917					88	99	31
424F	19	31	1	4004	6917					85	98	11
467F	19	31	4	4004	6917	VEAT		347		94	94	11
490F	19	31	5	4004	6917	4002	6907	363	9	70	93	11
505F	19	31	5	4004	6917	4009	6904	376	12	86	101	11
507F	19	31	5	4004	6917	4010	6845	379	25	60	80	11
510F	19	31	5	4004	6917	4013	6831	377	36	94		14
524F	19	31	5	4004	6917	HYDR		390		80		14
527F	19	31	6	4004	6917	HYDR		400		72	98	11
528F	19	31	6	4004	6917	HYDR		400		69	83	11
534F	19	31	6	4004	6917			398		68	82	11
543F	19	31	6	4004	6917	4013	7003	401	37	104	104	11
545F	19	31	6	4004	6917	3957	6929	410	12	85	100	11
554F	19	31	6	4004	6917	4009	6905	420	10	84	93	11
586F	19	31	9	4004	6917	4040	6939	504	41	86	97	11
602F	19	31	6	4004	6917	4008	6906	393	8	68		14
610F	19	31	7	4004	6917	4048	6812	443	66	97	111	51
614F	19	31	3	4004	6917	4004	6928	315	9	71		14
626F	19	31	10	4004	6917	HYDR		515		71	96	11
638F	19	31	11	4004	6917	4034	6933	563	33	70	86	12
640F	19	31	12	4004	6917	4007	6939	576	18	63	91	11
641F	19	31	12	4004	6917	4007	6939	576	18	87	98	12
643F	19	31	1	4004	6917			607		76		14
654F	19	31	6	4004	6917	4034	7003	41	47	77		14
655F	19	31	2	4004	6917			658		84	97	11
668F	19	31	4	4004	6917	3954	6932	699	14	98	112	31

Appendix Table 19 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
671F	19	31	5	4004	6917	4016	6832	736	35	60	90	14
673F	19	31	5	4004	6917	3956	6921	744	8	96	111	11
717F	19	31	1	4004	6917	HYDR		251		72	93	14
729F	19	31	6	4004	6917	HYDR		767		60		14
757F	19	31	8	4004	6917	HYDR		842		90	102	14
891F	19	31		4004	6917	HYDR				57		14
892F	19	31		4004	6917	HYDR				86		14
118M	19	31	5	4004	6917	VEAT		16		85		
119M	19	31	5	4004	6917	VEAT		17		86		
120M	19	31	5	4004	6917	VEAT		16		72		
121M	19	31	5	4004	6917	VEAT		16		76		
141M	19	31		4004	6917					96	96	
142M	19	31		4004	6917					109	109	
168M	19	31	6	4004	6917	VEAT		29		80		
188M	19	31	5	4004	6917			16		95		
190M	19	31	6	4004	6917	4009	6933	43	14	76		
194M	19	31	6	4004	6917	4007	6939	42	17	88	88	
215M	19	31	6	4004	6917	4000	6918	51	3	76		
246M	19	31	7	4004	6917	4049	6946	67	51	99	99	
290M	19	31	7	4004	6917	4004	7009	83	40	78		
317M	19	31	7	4004	6917	4133	6722	86	125	147		
331M	19	31	9	4004	6917	4014	6913	139	11	81		
344M	19	31	10	4004	6917			154		78		
356M	19	31	10	4004	6917			164		85		
363M	19	31	11	4004	6917	HYDR		195		90		
365M	19	31	11	4004	6917	4020	6941	199	26	115	133	
366M	19	31	11	4004	6917			195		103	125	
370M	19	31	11	4004	6917			195		73	89	
384M	19	31	11	4004	6917	4020	6934	210	22	107	125	
385M	19	31	11	4004	6917	4020	6934	210	22	78	96	
403M	19	31	12	4004	6917	4009	6904	220	10	69	84	
441M	19	31	1	4004	6917	4005	6908	270	7	78	91	
444M	19	31	1	4004	6917	4000	6937	255	16	115		
480M	19	31	4	4004	6917	4029	6711	335	98	74	89	
482M	19	31	5	4004	6917	3954	6926	364	11	75		
489M	19	31	5	4004	6917	4002	6907	363	9	81	97	
491M	19	31	5	4004	6917	VEAT		364		87	106	
496M	19	31	5	4004	6917	4009	6903	372	11	113	128	
501M	19	31	5	4004	6917	4006	6839	373	28	109		
512M	19	31	5	4004	6917	3956	6935	381	16	75	113	
530M	19	31	6	4004	6917			398		119	127	
532M	19	31	6	4004	6917			398		80	96	
561M	19	31	7	4004	6917	4049	6929	426	47	89	106	
570M	19	31	7	4004	6917	3954	7147	425	115	98	118	
574M	19	31	6	4004	6917	3957	7002	394	35	83		
577M	19	31	10	4004	6917	4117	6849	522	78	86	125	

Appendix Table 19 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
598M	19	31		4004	6917	HYDR	WELK			76		
601M	19	31	8	4004	6917	VEAT		461		73	88	
624M	19	31	10	4004	6917	HYDR		515		95	111	
642M	19	31	1	4004	6917			607		56		
677M	19	31	6	4004	6917	HYDR		407		73		
715M	19	31	4	4004	6917	HYDR		710		67	101	
756M	19	31	8	4004	6917	HYDR		842		63	99	
884M	19	30		3959	6925					81		

Appendix Table 20

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
148F	20	34	5	4101	6639	4113	6615	22	22	159	159	31
161F	20	33	6	4057	6635	4042	6656	27	22	121	121	31
169F	20	34	6	4101	6639			25		123		14
171F	20	33	6	4057	6635	4107	6626	34	11	146	146	11
172F	20	34	6	4101	6639	4059	6629	32	8	119	119	55
198F	20	33	6	4057	6635	4045	6649	42	16	115	115	31
207F	20	35	6	4101	6629	4103	6625	46	3	128	128	55
209F	20	34	6	4101	6639	4103	6625	46	10	129		55
228F	20	35	6	4101	6629	4053	6639	50	11	153	153	11
239F	20	34	6	4101	6639	4103	6625	48	10	133		11
244F	20	33	7	4057	6635	4120	6653	60	27	111	111	11
247F	20	34	7	4101	6639	4119	6638	62	18	130	130	55
252F	20	34	7	4101	6639	4129	6701	66	32	129	129	11
259F	20	35	7	4101	6629	4140	6702	70	47	145		14
276F	20	34	7	4101	6639	4139	6700	79	41	139	139	11
277F	20	34	7	4101	6639	4139	6700	79	41	157	157	11
281F	20	35	7	4101	6629			79		123	123	11
306F	20	33	8	4057	6635	4140	6718	100	54	161	161	11
314F	20	34	7	4101	6639	4133	6722	81	45	117		31
315F	20	33	7	4057	6635	4133	6722	82	50	182		31
338F	20	33	9	4057	6635	4130	6709	138	42	112		14
465F	20	34	4	4101	6639	CORS		350		147	147	11
497F	20	33	5	4057	6635			368		112	112	14
506F	20	33	4	4057	6635			348		162		14
578F	20	33	10	4057	6635	4058	6830	519	87	128		11
579F	20	34	10	4101	6639	4127	6708	517	34	188		11
611F	20	34	7	4101	6639	4131	6701	436	34	158		14
697F	20	33	6	4057	6635	3958	6926	761	143	136		34
885F	20	33	1	4057	6635	4035	6655	995	27	135	147	14
138M	20	33	5	4057	6635			12		163	163	
149M	20	34	5	4101	6639	4113	6615	23	22	134	134	
150M	20	33	5	4057	6635	4113	6615	23	22	139	139	
200M	20	35	6	4101	6629	4132	6649	43	35	177	177	
202M	20	33	6	4057	6635	4100	6628	44	6	195	195	
206M	20	33	6	4057	6635	4103	6625	48	9	171		
210M	20	34	6	4101	6639	4103	6625	48	10	141		
227M	20	34	6	4101	6639	4053	6639	51	8	125	125	
229M	20	33	6	4057	6635	4053	6639	52	6	136	136	
285M	20	35	8	4101	6629	4140	6705	94	48	176	176	
351M	20	34	10	4101	6639	4109	6707	157	23	156		
479M	20	33	4	4057	6635	4029	6711	329	40	148	148	
568M	20	34	7	4101	6639	4135	6652	429	35	146	170	
725M	20	34	6	4101	6639			773		109		
897M	20	33	4	4057	6635	4119	6616	1075	27	159		

Appendix Table 21

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
185F	21	36	6	4032	6748	4042	6657	7	40	132	132	11
186F	21	36	6	4032	6748	4010	6850	9	53	103	103	11
262F	21	36	7	4032	6748	4137	6654	44	76	120	120	11
399F	21	36	11	4032	6748	4020	6934	167	82	122	122	11
463F	21	36	4	4032	6748	4028	6710	308	29	170	170	11
502F	21	36	5	4032	6748	4035	6737	337	9	92	106	11
592F	21	36		4032	6748	HYDR	WELK			106		14
187M	21	36	6	4032	6748			9		103	103	
203M	21	36	6	4032	6748	4031	6744	16	2	157		
204M	21	36	6	4032	6748	4031	6744	16	2	101		
205M	21	36	6	4032	6748	4031	6744	16	2	98		
230M	21	36	6	4032	6748	4026	6733	22	12	112	112	
231M	21	36	6	4032	6748	4026	6733	22	12	114	114	
352M	21	36	10	4032	6748	4110	6901	117	67	117		
493M	21	36	3	4032	6748	4032	6705	295	32	126		
581M	21	36	9	4032	6748			478		171	183	
593M	21	36		4032	6748	HYDR	WELK			117		
594M	21	36		4032	6748	HYDR	WELK			93		
595M	21	36		4032	6748	HYDR	WELK			122		
630M	21	36	10	4032	6748	HYDR		482		122	143	
745M	21	36	10	4032	6748	4033	6742	859	5	189		
851M	21	36	11	4032	6748	4055	6810	885	28	133	160	
861M	21	36	12	4032	6748	OCEA		917		105	125	

Appendix Table 22

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
177F	22	38	6	4117	6633	4117	6639		4	177	177	11
178F	22	37	6	4108	6638	4117	6639	2	9	136	136	55
189F	22	37	6	4108	6638	4107	6636	4	2	164		11
208F	22	37	6	4108	6638	4103	6625	13	10	102		11
236F	22	38	7	4117	6633	4141	6704	20	33	141	141	11
237F	22	37	6	4108	6638	4024	6817	20	87	149	149	55
238F	22	37	7	4108	6638	4137	6654	21	32	157	157	11
251F	22	37	7	4108	6638	4136	6653	32	32	138	138	55
260F	22	37	7	4108	6638	4140	6702	38	37	117		54
280F	22	37	7	4108	6638			22		132		14
284F	22	38	8	4117	6633	4142	6659	60	32	134	134	31
287F	22	37	8	4108	6638	4140	6705	59	38	144	144	31
288F	22	37	8	4108	6638	4139	6700	59	38	122	122	11
293F	22	37	8	4108	6638	4140	6704	60	38	157	157	31
307F	22	37	8	4108	6638	4133	6732	72	48	114	114	31
308F	22	37	8	4108	6638	4133	6732	72	48	127	127	31
309F	22	37	8	4108	6638	4133	6732	72	48	101	101	11
316F	22	37	7	4108	6638	4133	6722	48	41	126		31
336F	22	37	9	4108	6638	4129	6727	89	42	124	137	32
337F	22	37	9	4108	6638	4129	6727	89	42	142	142	11
339F	22	37	9	4108	6638	4136	6723	86	44	133	133	11
432F	22	38	1	4117	6633			218		164	164	31
575F	22	37	8	4108	6638	4152	6956	431	155	122		51
597F	22	37		4108	6638	HYDR	WELK			139		14
600F	22	38	8	4117	6633	4138	6651	427	25	151	162	51
606F	22	38	9	4117	6633			451		150		54
770F	22	38	7	4117	6633	4115	6850	750	103	127	140	14
787F	22	37		4108	6638					172		14
222M	22	38	7	4117	6633	4134	6651	23	22	170	170	
242M	22	37	7	4108	6638	4139	6659	25	35	128	159	
243M	22	37	7	4108	6638	4142	6704	28	40	139	139	
248M	22	37	7	4108	6638	4141	6709	31	41	130	130	
258M	22	38	7	4117	6633	4140	6702	37	32	143	143	
261M	22	37	7	4108	6638	4138	6700	41	35	157	157	
278M	22	38	7	4117	6633	4139	6700	45	30	166	166	
303M	22	37	8	4108	6638	4011	6902	76	123	154	154	
305M	22	38	8	4117	6633			62		148	148	
310M	22	37	8	4108	6638	4144	6654	67	38	170	170	
341M	22	38	9	4117	6633	4140	6702	89	32	132		
342M	22	38	9	4117	6633	4140	6702	89	32	156		
354M	22	37	10	4108	6638	4112	6716	126	29	95	95	
378M	22	37	11	4108	6638	4110	6722	167	33	162	186	
652M	22	37	1	4108	6638					195		
722M	22	38	6	4117	6633	4048	6644	737	29	148	163	
747M	22	38	10	4117	6633	4025	6958	865	164	154		
898M	22	37	4	4108	6638	4105	6625	1034	11	121	168	

Appendix Table 23

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
565F	23	50	6	4018	6823	4022	6821	8	5	97	97	11
567F	23	48	6	4015	6827	4022	6821	9	8	118	118	11
576F	23	48	8	4015	6827	4050	6917	48	52	122	122	31
584F	23	48	9	4015	6827	4053	6841	84	39	85	97	11
646F	23	48	1	4015	6827	4010	6823	205	7	116	127	31
650F	23	48	1	4015	6827	4007	6904	198	29	111		54
651F	23	48	1	4015	6827	4007	6904	198	29	110		54
661F	23	48	3	4015	6827	4015	6809	266	15	88	101	11
662F	23	50	3	4018	6823	4015	6809	266	12	102	112	31
670F	23	48	5	4015	6827	4029	6742	337	37	90	103	14
672F	23	50	5	4018	6823	4011	6818	326	8	96	96	11
675F	23	48	4	4015	6827			311		90	104	31
728F	23	48	6	4015	6827	4011	7113	348	126	116	116	13
737F	23	48	7	4015	6827	4040	6810	377	28	110		33
739F	23	48	8	4015	6827	4026	6810	408	17	115		14
771F	23	48	6	4015	6827	4106	6847	361	54	88	102	14
775F	23	50	7	4018	6823	4040	6810	376	24	101		54
788F	23	50		4018	6823					103		14
842F	23	48	11	4015	6827	VEAT	HYDR	511		124	140	14
848F	23	50	11	4018	6823	4035	6825	506	16	103		34
550M	23	48	6	4015	6827	4020	6825	6	6	132	132	
556M	23	48	6	4015	6827	4020	6818	8	8	115		
557M	23	48	6	4015	6827	4020	6818	8	8	95		
562M	23	48	7	4015	6827	4035	7009	16	80	86	86	
564M	23	50	7	4018	6823	4035	7009	15	83	117	117	
659M	23	48	2	4015	6827			241		143		
665M	23	48	4	4015	6827	4006	6849	286	18	114	134	
666M	23	48	4	4015	6827	4006	6849	291	18	110	128	
736M	23	48	7	4015	6827	4040	6810	377	28	104		
767M	23	48	7	4015	6827	4100	6922	389	62	135	158	
769M	23	48	7	4015	6827	4115	6850	377	60	88	102	
774M	23	48	7	4015	6827	HYDR		404		90		
789M	23	48		4015	6827					90		
797M	23	48	7	4015	6827	4135	6646	404	112	104		

Appendix Table 24

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
549F	24	49	6	4024	6825	4020	6825	6	6	103	103	55
558F	24	51	6	4027	6815	4020	6818	5	7	102		14
569F	24	51	7	4027	6815	3959	6946	16	74	116		14
580F	24	49	9	4024	6825			100		116	116	54
631F	24	49	10	4024	6825	HYDR		104		81	93	11
636F	24	51	11	4027	6815	4029	6820	149	3	110	123	31
719F	24	51	6	4027	6815	4019	6824	361	11	110	110	14
727F	24	51	5	4027	6815	4026	6809	343	6	90	103	14
765F	24	51	11	4027	6815	HYDR		498		73	73	44
776F	24	51	7	4027	6815	4040	6810	383	14	97		54
778F	24	51	7	4027	6815	HYDR		379		85		44
883F	24	51	11	4027	6815	4017	6833	512	18	98		11
936F	24	51	7	4027	6815			766		157	163	14
947F	24	51	8	4027	6815			781		145		54
566M	24	51	6	4027	6815	4022	6820	6	7	98	98	
635M	24	49	11	4024	6825	4029	6820	152	8	111	129	
637M	24	49	11	4024	6825	4029	6820	152	8	107	107	
648M	24	51	1	4027	6815	4017	7113	207	136	136	136	
653M	24	49	1	4024	6825	4016	6809	220	16	99	115	
746M	24	49	10	4024	6825	4033	6742	481	34	95		
773M	24	51	7	4027	6815	HYDR		383		107		
777M	24	51	7	4027	6815	4040	6810	383	14	123		

Appendix Table 25

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
718F	25	57	2	4002	7115	3959	7119	38	5	82		14
735F	25	58	6	3958	7110	3958	7110	169		109		11
791F	25	58	8	3958	7110	4010	7107	209	12	108	108	44
798F	25	58	6	3958	7110	4007	7000	163	54	113		31
927F	25	57	6	4002	7115	4012	7040	412	29	76	90	14
928F	25	57	6	4002	7115	4012	7040	412	29	75	92	14
734M	25	58	7	3958	7110	3958	7110	184		90		
792M	25	58	8	3958	7110	4008	7056	210	15	107		
920M	25	57	6	4002	7115	4002	7119	530	4	104	125	
921M	25	57	6	4002	7115	4005	7118	524	5	83		

Appendix Table 26

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
674M	26	59	5	3914	7220			112		103	103	

Appendix Table 27

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
740F	27	62	9	3756	7356	3835	7440	227	52	125		14
914F	27	60	6	3754	7402	3744	7409	494	12	124		14
915F	27	60	7	3754	7402	3813	7348	526	22	141		14
916F	27	60	7	3754	7402	3813	7348	526	22	129		14
917F	27	61	9	3755	7358	3900	7434	230	71	98		14
935F	27	60	4	3754	7402	3800	7355	448	9	150		15
880M	27	60	1	3754	7402	3813	7357	329	20	121		
911M	27	60	7	3754	7402	3813	7348	526	22	72		
912M	27	62	7	3756	7356	3752	7407	516	8	97		
913M	27	60	7	3754	7402	3813	7348	536	22	130		
954M	27	62	10	3756	7356	3800	7355	620	4	101		

Appendix Table 28

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
906F	28	64	6	3910	7239	3902	7242	479	9	123		21
663M	28	64	3	3910	7239	3906	7243	36	7	161	161	
664M	28	64	3	3910	7239	3906	7243	36	7	146	146	

Appendix Table 29

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
682F	29	66	6	4002	6932	4002	6932	28		76		11
684F	29	66	6	4002	6932	4002	6932	28		95	95	33
685F	29	65	6	3958	6926	3958	6926	30		100	100	33
686F	29	66	6	4002	6932	4002	6932	28		87	87	33
687F	29	65	6	3958	6926	3958	6926	30		81		14
689F	29	66	6	4002	6932	4002	6932	28		76		14
690F	29	65	6	3958	6926	3958	6926	30		73		14
691F	29	65	6	3958	6926	3958	6926	30		78		14
695F	29	65	6	3958	6926	3958	6926	30		66		11
698F	29	66	6	4002	6932	4002	6932	28		77		14
699F	29	66	6	4002	6932	4002	6932	31		76		14
701F	29	65	6	3958	6926	4000	6923	44	3	80	95	14
702F	29	66	6	4002	6932	4000	6923	42	7	103		34
703F	29	65	6	3958	6926	4000	6923	44	3	76		14
705F	29	65	6	3958	6926	4000	6923	44	3	71		11
710F	29	65	6	3958	6926	4000	6923	44	3	74		14
712F	29	66	6	4002	6932	4000	6932	42	7	76		14
721F	29	65	6	3958	6926	4048	6924	49	50	108	108	33
738F	29	65	7	3958	6926	4048	6924	53	38	102		33
743F	29	65	7	3958	6926			80		92		14
750F	29	65	8	3958	6926	HYDR		108		117	117	34
751F	29	65	8	3958	6926	HYDR		108		72	72	14
752F	29	65	8	3958	6926	HYDR		108		72	86	14
753F	29	65	8	3958	6926	HYDR		108		84	105	34
755F	29	65	8	3958	6926	HYDR		108		68	82	14
760F	29	66	10	4002	6932	HYDR		152		78	78	14
761F	29	65	10	3958	6926	HYDR		154		76	92	14
763F	29	65	11	3958	6926	HYDR		178		104	115	34
764F	29	65	11	3958	6926	HYDR		178		77	90	14
779F	29	65	7	3958	6926	4035	6910	79	39	81	91	14
780F	29	65	11	3958	6926			185		75	90	14
781F	29	65	11	3958	6926			186		74	87	14
782F	29	65	11	3958	6926	HYDR		184		101	116	14
783F	29	65	11	3958	6926	HYDR		184		116	130	14
790F	29	65	8	3958	6926			96		93	93	14
793F	29	65	8	3958	6926	VEAT		87		105	105	14
794F	29	66	8	4002	6932	VEAT		85		70	85	14
795F	29	65	8	3958	6926	VEAT		87		114	114	14
796F	29	65	8	3958	6926	VEAT		87		117	117	31
805F	29	65	9	3958	6926			130		75	88	11
807F	29	65	9	3958	6926	VEAT	HYDR	130		99	114	31
808F	29	65	9	3958	6926	VEAT	HYDR	130		72	85	11
809F	29	66	9	4002	6932	VEAT	HYDR	128		85	100	31
810F	29	66	9	4002	6932	VEAT	HYDR	128		75	90	14
811F	29	65	9	3958	6926	VEAT	HYDR	130		104	116	31
813F	29	65	9	3958	6926	VEAT	HYDR	130		72	88	14
814F	29	65	9	3958	6926	VEAT	HYDR	130		102	115	31
815F	29	65	9	3958	6926	VEAT	HYDR	130		105	122	31
816F	29	65	9	3958	6926	VEAT	HYDR	130		76	93	11
817F	29	65	9	3958	6926	VEAT	HYDR	130		72	87	14

Appendix Table 29 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
818F	29	65	9	3958	6926	VEAT	HYDR	130		77	95	14
820F	29	65	9	3958	6926	VEAT	HYDR	130		71	86	14
821F	29	65	9	3958	6926	VEAT	HYDR	130		70	85	14
822F	29	65	9	3958	6926	VEAT	HYDR	130		73	87	14
826F	29	65	11	3958	6926	HYDR		196		81	95	14
827F	29	65	11	3958	6926	HYDR		196		106	115	31
829F	29	65	11	3958	6926	VEAT		181		96		34
830F	29	65	11	3958	6926	VEAT		181		75		14
832F	29	65	11	3958	6926	VEAT	HYDR	188		72	88	14
833F	29	65	11	3958	6926	VEAT	HYDR	188		73	90	14
835F	29	65	11	3958	6926	VEAT	HYDR	188		77	91	31
837F	29	66	11	4002	6932	VEAT	HYDR	186		87	98	31
838F	29	66	11	4002	6932	VEAT	HYDR	186		103	116	31
839F	29	65	11	3958	6926	VEAT	HYDR	188		74	87	14
840F	29	65	11	3958	6926	VEAT	HYDR	188		99	109	31
841F	29	65	11	3958	6926	VEAT	HYDR	188		113	125	31
844F	29	65	11	3958	6926	VEAT	HYDR	188		71	86	14
845F	29	66	11	4002	6932	VEAT	HYDR	186		94	107	31
846F	29	65	11	3958	6926	VEAT	HYDR	188		99	112	31
847F	29	65	11	3958	6926	VEAT	HYDR	188		95	108	31
850F	29	65	11	3958	6926	4025	6855	178	35	87	104	31
853F	29	65	10	3958	6926	OCEA		173		93	104	31
855F	29	65	11	3958	6926	HYDR		204		87	100	31
858F	29	65	11	3958	6926	OCEA		200		78	90	11
859F	29	65	12	3958	6926	HYDR		211		102	115	31
862F	29	65	12	3958	6926	OCEA		211		91	105	11
867F	29	65	12	3958	6926	4005	6925	213	7	92		34
871F	29	65	12	3958	6926	4005	6925	213	7	71		14
872F	29	65	12	3958	6926	4005	6925	213	7	113		34
874F	29	65	12	3958	6926			221		77	93	14
876F	29	65	12	3958	6926	VEAT	HYDR	210		100	115	34
878F	29	65	12	3958	6926	VEAT	HYDR	210		103	116	34
881F	29	66	11	4002	6932	4017	6833	190	47	67		14
882F	29	65	11	3958	6926	4017	6833	192	45	72		14
886F	29	65	1	3958	6926	HYDR	WELK	242		70	83	11
888F	29	65	1	3958	6926	HYDR	WELK	242		76	91	14
889F	29	65	1	3958	6926	HYDR	WELK	242		74	86	14
890F	29	65	1	3958	6926	3955	6935	250	8	114	130	34
902F	29	66	2	4002	6932	HYDR		267		98		14
907F	29	65	6	3958	6926	3955	6935	396	8	104	118	14
910F	29	65	7	3958	6926	VEAT		428		80	93	14
919F	29	65	6	3958	6926			407		77		14
922F	29	65	6	3958	6926	4005	6900	416	21	92		14
923F	29	66	6	4002	6932	4005	6900	414	25	94		34
924F	29	65	6	3958	6926	4005	6900	416	21	95		34
926F	29	65	6	3958	6926	4012	7040	414	58	81	97	14
929F	29	65	7	3958	6926	4005	7020	428	42	78	90	14
930F	29	65	7	3958	6926	4005	6945	438	16	75	89	14
931F	29	65	7	3958	6926	4005	6945	432	16	78	108	14
941F	29	65	10	3958	6926	HYDR		532		72	100	14

Appendix Table 29 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
948F	29	65	7	4001	6930	HYDR		420		110		34
949F	29	65	7	4001	6930	HYDR		429		69		14
950F	29	66	7	4002	6932	HYDR		421		101		34
951F	29	65	6	4001	6930	HYDR		419		117		34
953F	29	65	9	4001	6930	4005	6908	492	18	63		14
680M	29	66	6	4002	6932	4002	6932	28		74		
681M	29	65	6	3958	6926	3958	6926	30		72		
683M	29	65	6	3958	6926	3958	6926	30		77		
688M	29	66	6	4002	6932	4002	6932	28		77		
692M	29	65	6	3958	6926	3958	6926	30		80		
694M	29	65	6	3958	6926	3958	6926	30		79		
696M	29	65	6	3958	6926	3958	6926	30		79		
700M	29	65	6	3958	6926	4000	6923	44	3	80		
704M	29	65	6	3958	6926	4000	6923	44	3	72		
706M	29	65	6	3958	6926	4000	6923	44	3	78		
707M	29	65	6	3958	6926	4000	6923	44	3	78		
708M	29	65	6	3958	6926	4000	6923	44	3	69		
709M	29	65	6	3958	6926	4000	6923	44	3	74		
711M	29	66	6	4002	6932	4000	6923	42	7	79		
754M	29	65	8	3958	6926	HYDR		108		74	90	
758M	29	65	8	3958	6926	4125	7056	108	111	76	91	
766M	29	65	7	3958	6926	HYDR		81		72		
806M	29	65	9	3958	6926	VEAT	HYDR	130		80	98	
812M	29	65	9	3958	6926	VEAT	HYDR	130		77	95	
819M	29	65	9	3958	6926	VEAT	HYDR	130		80	95	
823M	29	65	9	3958	6926	VEAT	HYDR	130		75	94	
824M	29	65	9	3958	6926	VEAT	HYDR	130		77	94	
828M	29	65	11	3958	6926	VEAT		181		78		
831M	29	65	11	3958	6926			188		70	85	
834M	29	65	11	3958	6926	VEAT	HYDR	188		78	95	
836M	29	65	11	3958	6926	VEAT	HYDR	188		81	98	
843M	29	65	11	3958	6926	VEAT	HYDR	188		80	96	
854M	29	66	11	4002	6932	HYDR		202		73	89	
860M	29	65	11	3958	6926	HYDR		186		74		
864M	29	65	12	3958	6926	4005	6925	213	7	66		
865M	29	65	12	3958	6926	4005	6925	213	7	81		
866M	29	65	12	3958	6926	4005	6925	213	7	68		
868M	29	65	12	3958	6926	4005	6925	213	7	70		
869M	29	65	12	3958	6926	4005	6925	213	7	74		
873M	29	65	12	3958	6926	4005	6925	213	7	72		
877M	29	66	12	4002	6932	VEAT	HYDR	208		70	86	
887M	29	65	1	3958	6926	HYDR	WELK	242		78	91	
895M	29	65	12	3958	6926	3955	7135	221	102	81		
896M	29	65		3958	6926	HYDR				72		
899M	29	65	4	3958	6926	3958	6950	354	18	83	101	
900M	29	65	3	3958	6926	4025	6955	308	35	77	94	

Appendix Table 29 Cont.

RET	CS	OS	MO	RLAT	RLON	CLAT	CLON	DATL	MIL	CL1	CL2	EC
901M	29	65	2	3958	6926	HYDR		269		77	92	
903M	29	65	2	3958	6926	HYDR		269		71		
904M	29	65	11	3958	6926	OCEA		193		71		
909M	29	65	5	3958	6926	4005	7025	361	46	78	96	
925M	29	65	6	3958	6926	4010	6905	417	20	68	80	
939M	29	65	8	3958	6926	4010	6940	465	16	69		
942M	29	65	10	3958	6926	HYDR		532		74	110	
945M	29	65	9	3958	6926			496		80	101	
952M	29	65	7	4001	6930	HYDR		442		69		

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Food of Western North Atlantic Tunas (*Thunnus*) and Lancetfishes (*Alepisaurus*)

Frances D. Matthews, David M. Damkaer,
Leslie W. Knapp, and Bruce B. Collette

January 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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NOAA Technical Report NMFS SSRF -706

Food of Western North Atlantic Tunas (*Thunnus*) and Lancetfishes (*Alepisaurus*)

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January 1977

U.S. DEPARTMENT OF COMMERCE
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Food of Western North Atlantic Tunas (*Thunnus*) and Lancetfishes (*Alepisaurus*)

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ABSTRACT

Stomach contents of 395 longline-caught specimens of *Thunnus* (281 *T. albacares*, 52 *T. t. thynnus*, 48 *T. alalunga*, 14 *T. obesus*) and 89 *Alepisaurus* were examined. About 45% of the tuna's food, by volume, was composed of fishes, 35% of cephalopods, 15% of crustaceans, and 5% of miscellaneous items. Fishes eaten by tunas ranged in length 9-360 mm SL ($\bar{x}$ 65 mm) and represented a minimum of 88 genera in 58 families. Fishes eaten by *Alepisaurus* were 8-846 mm SL ($\bar{x}$ 98 mm) and represented 40 genera in 34 families. Most forage fishes were immature forms of midwater and shore fishes, many of which are associates of the pelagic *Sargassum* community. Ten of the most frequently occurring families in *Thunnus* and *Alepisaurus* stomachs were Bramidae, Alepisauridae, Balistidae, Paralepididae, Scombridae, Sternoptychidae, Carangidae, Tetraodontidae, Gempylidae, and Syngnathidae.

Cephalopods were the most frequently occurring (80-90%) invertebrate group in the tuna stomachs, particularly the squid family Ommastrephidae. Crustaceans followed the cephalopods in frequency of occurrence (30-80% depending on tuna species). Larval decapods and hyperiid amphipods were the principal groups of crustaceans. In *Alepisaurus* stomachs, cephalopods occurred with 50% frequency, usually octopods and soft-bodied squids, families Cranchiidae, Histioteuthidae, and Bathyteuthidae. Crustaceans were present in 75% of *Alepisaurus* stomachs. Fewer decapod larvae were found than in the tunas, while amphipods were found more frequently. Pelagic polychaetes (Family Alciopidae), not found in any tunas, occurred in 38% of *Alepisaurus* specimens.

Differences in the relative importance of particular forage categories in the diet of different species of *Thunnus* and between the diets of *Thunnus* and *Alepisaurus* suggest interspecific differences in feeding, either anatomical (i.e., relative predatory ability) or behavioral, particularly the relative swimming speeds and feeding depths of different predators. The small-mouthed tunas consumed generally smaller prey fishes ($\bar{x}$ 98 mm SL) than did the large-mouthed lancetfishes ($\bar{x}$ 240 mm SL). Smaller sized yellowfin tunas generally consumed smaller prey than did larger yellowfins. Differences in swimming ability between tunas and *Alepisaurus* were reflected in the larger number of swift-moving muscular squids eaten by the tunas. Composition of the forage indicated that *T. albacares* fed at shallower depths than the other species of *Thunnus* and that *Alepisaurus* fed at greater depths than any of the tunas.

INTRODUCTION

In the past 20 yr, the tunas have become objects of intensified commercial and recreational fisheries. Heavy utilization of these fishes and subsequent concern about the limitation of stocks have made an understanding of their biology increasingly important. Because the tunas are peak predators in a vast part of the epipelagic zone, one important aspect of investigation is their feeding habits. Numerous forage studies have been carried out in all parts of the world for the tunas of the genus *Thunnus* and the skipjack genus *Katsuwonus*. Most information has been reported on a qualitative basis, however, and many studies have been based upon small samples. For the Atlantic Ocean, Dragovich (1969) reviewed the important literature on tuna feeding habits published until that time. Since then, several important contributions have been added for the Atlantic: Dragovich reported on the food of skipjack and yellowfin tuna in the Atlantic (1970a) and the bluefin tuna in the eastern tropical Atlantic (1970b); Dragovich and Potthoff (1972) compared the food of the yellowfin and skipjack off the coast of West Africa, and Borodulina (1974) reported on the feeding of bigeye tuna in the Gulf of Guinea.

Literature on Pacific tunas has not been similarly summarized. Important contributions include investigations on the feeding of yellowfin in the central Pacific (Reintjes and King 1953) and the comparison of the food of central Pacific bigeye and yellowfin (King and Ikehara 1956). Alverson (1963) compared the forage of yellowfin and skipjack in the eastern tropical Pacific. Iversen (1962) studied the food habits of albacore in the central and northeastern Pacific. Iversen (1971) reported on albacore and Pinkas (1971) reported on bluefin feeding habits in Californian waters.

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In the present study, we examined the stomach contents of four species of *Thunnus* in the western North Atlantic: *T. albacares* (Bonnaterre), the yellowfin; *T. alalunga* (Bonnaterre), the albacore; *T. t. thynnus* (Linnaeus), the Atlantic bluefin; and *T. obesus* (Lowe), the bigeye. The specimens examined were obtained during a series of exploratory longline cruises over the period 1957-64 by the Bureau of Commercial Fisheries (now National Marine Fisheries Service) MV *Delaware*, before a major fishery was established in the region. While fishing for tunas, lancetfishes of the genus *Alepisaurus* were often hooked by the longline. In this capacity at least, the lancetfishes were competing with tunas; being thus an apparent competitor, it seemed worthwhile to examine also the stomach contents of *Alepisaurus* taken with *Thunnus*. *Alepisaurus* forage has previously been investigated in the Atlantic by Haedrich (1964). Parin et al. (1967) reported on the feeding habits of *Alepisaurus* in the Indian Ocean. In the Pacific, lancetfish feeding habits have been reported on by Haedrich and Nielsen (1966), Kubota and Uyeno (1969), Rancurel (1970), and Kubota (1973).

Included in the present study are both species of lancetfishes, *Alepisaurus ferox* Lowe and *A. brevirostris* Gibbs. No distinction is made between species, however, because much of the data were collected before the latter was described by Gibbs (1960).

MATERIALS AND METHODS

We examined the contents of 395 *Thunnus* stomachs (281 *T. albacares*, 52 *T. t. thynnus*, 48 *T. alalunga*, and 14 *T. obesus*) and those of 89 *Alepisaurus*. Number, size range, and mean size of the *Thunnus* and *Alepisaurus* specimens are presented in Table 1. All specimens were collected by longline from the western North Atlantic off the eastern coast of the United States north of Bermuda and, on one cruise, east to the Azores (Figure 1). Specimens were taken from depths of 10-60 m. Longline gear and methods used were described by Squire (1962) and Wilson and Bartlett (1967).

Most of the *Thunnus* stomach contents were collected by Robert H. Gibbs, Jr. and Bruce B. Collette in conjunction with a study of the anatomy and systematics of the genus *Thunnus* (Gibbs and Collette 1967). Methods to obtain stomach contents were used that would not damage the tuna specimens. The stomach contents of *Thunnus* were obtained through a longitudinal ventral incision through which the stomach was pulled, the contents were removed, and the emptied stomach pushed back into place. As a result, the total contents were not always obtained. The stomach contents that were collected for each specimen were preserved in 10% Formalin. Size (mm fork length (FL)) and weight of the tuna were usually recorded.

Alepisaurus stomach contents were obtained by shaking the specimen head-down over a bucket, after the removal from the longline hook. The lancetfish's wide mouth, esophagus, and stomach allowed its stomach contents to fall out readily into the collection bucket. Contents were then preserved in 10% Formalin.

Some stomach contents were identified at sea, recorded, and discarded; others were identified at the Woods Hole Oceanographic Institution and Boston University.

Table 1.—Numbers, size ranges, and mean sizes of *Thunnus* spp. and *Alepisaurus* examined.

	N	Size range (cm FL)	$\bar{x}$
Thunnus albacares	281	74-166	114
Thunnus alalunga	48	96-106	101
Thunnus thynnus	52	158-232	188
Thunnus obesus	14	142-165	149
Alepisaurus sp.	89	48-138	—

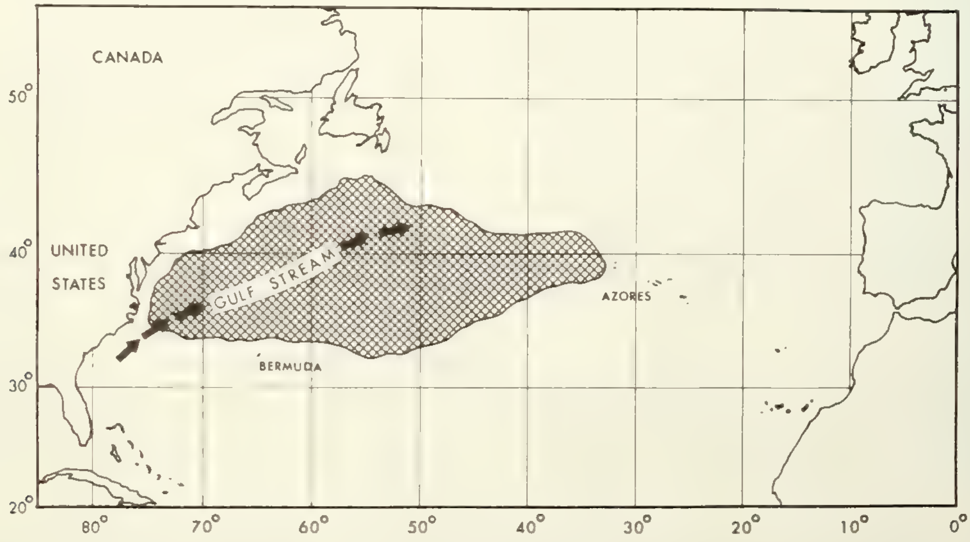

Figure 1.—Area sampled (crosshatched) for *Thunnus* and *Alepisaurus* by longline in the western North Atlantic.

Heteropods and pteropods from this collection were removed and reported on by Russell (1960). The bulk of the material was then transferred to the National Marine Fisheries Service Systematics Laboratory at the U.S. National Museum of Natural History. To facilitate identification, the stomach contents were divided into broad categories: fishes, cephalopods, other mollusks, crustaceans, jellyfish, and miscellaneous. D. M. Damkaer identified the crustaceans and, under the guidance of Clyde Roper (a specialist in cephalopod taxonomy), the cephalopods and the remainder of the invertebrates. Leslie Knapp (Smithsonian Oceanographic Sorting Center (SOSC)) supervised the identification of the fishes with the assistance of several specialists on the SOSC list. Representative specimens of forage species in good or fair condition have been deposited in the relevant collections of the National Museum of Natural History (worms, mollusks, crustaceans, and fishes).

The identification of forage specimens depended on the degree to which digestion had damaged the organism and on its stage of maturity, particularly in the crustaceans and cephalopods. Fishes were more completely identified than were other groups, usually to family and often to species. A large portion of the invertebrate forage could be identified only to order or superfamily. Therefore, the number of taxa from any one category of forage organisms, while giving a picture of the diversity of forage, should not be considered quantitatively.

The relative importance of a forage category can conveniently be thought of in terms of the amount of energy it affords its predator, measured by number and size of a particular organism eaten. The frequency with which an organism is eaten, furthermore, often gives a rough estimate of its general availability to a predator. To evaluate the composition of forage, therefore, we used these three measurements: 1) Frequency was calculated as percent frequency of occurrence, e.g., in what percentage of the total number of stomachs examined a particular organism was found. 2) The number of individuals per stomach from a particular forage group was compared numerically. 3) The size of a forage organism was expressed as length: crustaceans as mm total length, cephalopods as mm mantle length, and fishes as mm standard length (SL, tip of snout to the base of the caudal fin). Accuracy of measurement was dependent upon the degree to which the forage specimen had been digested; approximations were often made in cases where skeletons were incomplete, but suggestive of the organism's full size.

We considered a forage organism to be of greatest importance when it was eaten with relatively high frequency, was comparatively larger than other forage organisms eaten, and was consumed by an individual predator in larger numbers than the mean number of other forage groups present in that stomach. The less important a forage organism appeared in these three aspects, relative to the other organisms eaten, the less important it was considered to the predator's diet. No statistical tests were applied.

RESULTS

Taxonomic lists of forage components of *Thunnus* and *Alepisaurus* are presented in Appendix Table 1. Forage organisms which are additions to taxa listed for the Atlantic Ocean by Dragovich (1969) for *Thunnus* or by Haedrich (1964) for *Alepisaurus* are noted. Fishes, crustaceans, and mollusks made up the bulk of the collection. Medusae, salps, *Sargassum*, and parasitic nematodes and trematodes, which are not included in the forage lists, were also present. The forage composition for all *Thunnus* species consisted of, by volume, about 45% fishes, 35% cephalopods, 15% crustaceans, and 5% miscellaneous items.

Vertebrate Forage (Fishes)

Fishes occurred with a frequency of 66-100%, depending on the species of predator. Those consumed by tunas ranged in length 9-360 mm SL ($\bar{x}$ 65 mm) and represented 88 genera in 58 families. Fishes eaten by *Alepisaurus* varied over a greater size range (8-846 mm SL, $\bar{x}$ 98 mm) and represented 40 genera in 34 families. The majority of forage fishes in *Thunnus* and *Alepisaurus* were immature forms of midwater fishes and epipelagic post-larvae and juveniles of shore fishes.

Fish were present in 95% (266 stomachs) of the *T. albacares* stomachs examined. Evaluation of fish forage composition is based on 209 stomachs, however, in which fishes were identifiable. Of the 48 *T. alalunga* examined, 79% (38 stomachs) contained fish. Evaluation is based on 14 stomachs containing identifiable specimens. Seventy-three percent (38 stomachs) of the *T. thynnus* consumed fish. Forage composition analysis is based on 24 stomachs containing identifiable specimens. Forage fish were present in all 14 of *T. obesus* examined, but could be identified further in only eight.

The contents of *Alepisaurus* stomachs were generally in better condition than those from the tunas. Ninety-one percent (81 stomachs) of the *Alepisaurus* specimens examined had consumed fish, most of which were identifiable at least to family. The percent identifiable from *Alepisaurus* stomachs may be larger than from tunas because identification was easier, perhaps because digestion in *Alepisaurus* takes place mainly in the intestine, the stomach being used only for storage (Rofen 1966).

Thunnus albacares.—Forty families of fishes were found in the stomachs of yellowfin (Appendix Table 2). Those which occurred with at least 1% frequency are included in Figure 2.

Ten families occurred with 10% frequency or more: Balistidae, 41%; Carangidae, 31%; Bramidae, 24%; Chiasmodontidae, 21%; Syngnathidae, 18%; Priacanthidae, 13%; Tetraodontidae, 13%; Holocentridae, 12%; Acanthuridae, 11%; and Scombridae, 10%. Except for the Scombridae, none was outstanding in either size or number. In most families, one genus or one species was chiefly responsible for its high frequency: *Monacanthus* spp., *Caranx* sp., *Pterycombus* sp.,

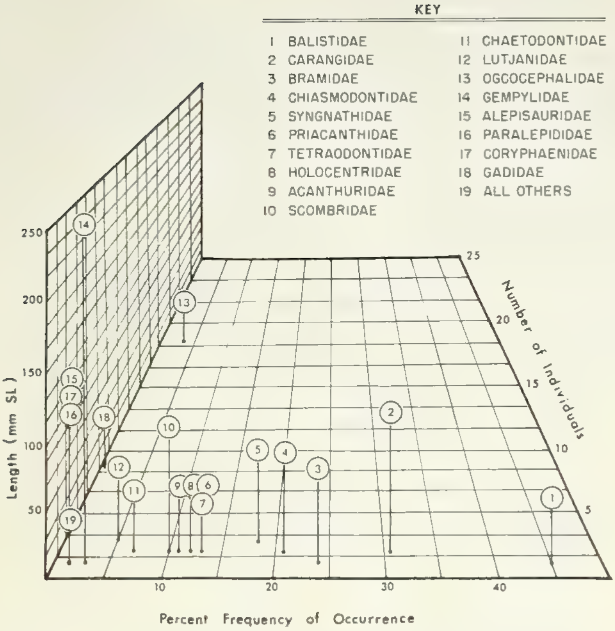

Figure 2.—Relative importance of families of fishes present in more than 1% of the stomachs of western North Atlantic *Thunnus albacares*. Percent frequency of occurrence is on the horizontal axis, mean length (mm SL) of forage family on the vertical axis, and mean number of individuals in a forage family on the third axis. The most important families are those that occur more frequently (to the right on the horizontal axis), average larger in size (lines coming up from the horizontal axis), and are the most numerous (displaced back into page on third axis).

Pseudoscopelus sp., *Hippocampus erectus*, *Cookeolus boops*, *Sphoeroides* sp., and *Auxis* sp. were of primary importance (Appendix Table 2). The occurrence of 32 *Cookeolus boops* (13-66 mm SL) in 26 stomachs of *T. albacares* is of interest because only 13 specimens of this species have previously been recorded from the western Atlantic (Anderson et al. 1972). One of these was identified by Caldwell (1962) from the stomach of one of the *T. albacares* collected during this study.

Fishes eaten by yellowfin varied in length 11-360 mm SL, $\bar{x}$ 45 mm SL. Gempylids ($\bar{x}$ 216 mm), *Coryphaena* ($\bar{x}$ 141 mm), *Alepisaurus* ($\bar{x}$ 120 mm), paralepidids ($\bar{x}$ 105 mm), and scombrids ($\bar{x}$ 96 mm) were the largest forage fishes. Except for the Scombridae, they were present in only a few stomachs and in small numbers. Ogcocephalidae, although eaten infrequently and among the smallest ($\bar{x}$ 17 mm SL) forage fishes, was the only family to occur in large numbers (43 in one stomach, average 19). No fishes which were eaten in large numbers, or which were outstanding in size, occurred with greater than 6% frequency, except for the Scombridae.

***Thunnus alalunga*.**—Fishes consumed by *T. alalunga* belonged to 21 families (Appendix Table 3). They averaged slightly smaller ($\bar{x}$ 40 mm SL) than fishes eaten by *T. albacares*. Gempylidae and Paralepididae were the most important forage families in terms of size and frequency of occurrence. Gempylids consisted mostly of *Diplospinus multistriatus* which was present in 36% of the stomachs and was the largest sized group ($\bar{x}$ 151 mm SL). Paralepididae occurred in 29% of the stomachs and averaged 101 mm SL. Bramidae were present in 64% of the stomachs examined, but were less important in terms of size. *Omosudis lowei* was also frequently eaten, although the family Omosudidae as a whole did not occur frequently. The only group to occur in large numbers was Ogcocephalidae, 40 of which were present in a single stomach.

***Thunnus thynnus*.**—The food of *T. thynnus* included 17 families of fishes (Appendix Table 4). Bramidae (38%) were the most frequently occurring, with *Collybus drachme* and *Taractes* spp. (both present with 8% frequency) being chiefly responsible for the high frequency of the whole family. Balistidae (17%) were also consumed frequently. *Alepisaurus* sp., *Auxis* sp., and *Hippocampus erectus* occurred relatively frequently, though the frequencies of their families were not particularly high.

The size range of forage fishes was 29-230 mm SL. No single family appeared to be unusually large in size, although *T. thynnus* forage fishes were larger on the average ($\bar{x}$ 107 mm SL) than those eaten by either *T. albacares* ($\bar{x}$ 45 mm SL) or *T. alalunga* ($\bar{x}$ 37 mm SL), while they were smaller than those of *T. obesus* ($\bar{x}$ 213 mm SL).

***Thunnus obesus*.**—Nine families and six genera of fishes were identified from 14 *T. obesus* stomachs: Alepisauridae, Balistidae, Belonidae, Bramidae, Caproidae, Melamphaidae, Nemichthyidae, Paralepididae, and Trachipteridae. Only two families occurred in more than one stomach: Paralepididae, in three (37% frequency), and Alepisauridae, in two (25% frequency). The fishes eaten by *T. obesus* were on the whole larger than those consumed by the other species of *Thunnus*. The smallest was 83 mm SL; others ranged up to 340 mm ($\bar{x}$ 213 mm SL).

***Alepisaurus*.**—Thirty-eight genera of fishes from 36 families were found in the stomach contents of *Alepisaurus* (Appendix Table 5). The five most common families included most of the largest fishes eaten. Paralepididae ($\bar{x}$ 124 mm SL) was the most frequently occurring family, present in 53% of the stomachs examined. Several *Paralepis coregonoides* measured 600-846 mm SL. Gempylidae ranked high in both size ($\bar{x}$ 105 mm SL) and occurrence (27%). Alepisauridae were the largest prey group eaten ($\bar{x}$ 213 mm SL) and were present in 12% of the stomachs. Sternoptychids were present in 27% of the stomachs. They were not outstanding in size but were often consumed in large numbers—as many as 54 in one stomach. Bramidae were present in 11% of the stomachs, although they were not important in either size or number.

Invertebrate Forage

Most taxa of invertebrate forage belonged to two groups, Mollusca and Crustacea (Appendix Table 1). Salps and scyphozoan medusae were also present, but were not identifiable.

***Thunnus*.**—Cephalopods were the most frequently occurring invertebrates (80-90%) in the stomachs of all species of *Thunnus* (Appendix Tables 6-8). Crustaceans were present in 30-80% of the stomachs, depending on the species of tuna. In stomachs where the two groups co-occurred, the percent-volume ratios of cephalopods: crustaceans were about 75:25 (range 67-79:21-33). Cephalopods were, furthermore, more often the exclusive content of a stomach than were crustaceans (Appendix Table 10). Heteropods and pteropods were also abundant, more so than indicated in our tables because they were removed from many samples by Russell (1960).

Cephalopods were the largest invertebrates eaten (mantle lengths up to 200 mm). The most voluminous and abundant were species of the family Ommastrephidae. *Gonatus fabricii* (Gonatidae) was also common. The most common octopods were the species of *Argonauta* (including *A. argo*) and *Alloposus mollis*. Surface-dwelling *Argonauta* occurred far more often in the stomachs of *T. albacares* (36%) and *T. thynnus* (25%) than in *T. alalunga* (8%), and was not found in *T. obesus* (Appendix Table 11). The gelatinous octopod, *Alloposus mollis*, was frequently consumed by *T. thynnus* (48% frequency), but rare or absent in the diet of other species of tunas.

Even though abundant, pteropods and heteropods are not as important a component of the forage as are cephalopods and crustaceans because of the small size of these mollusks. They occurred in 52% of the *T. thynnus* stomachs examined (Appendix Table 8). Russell (1960) found the heteropod *Carinaria lamarcki* in *T. albacares* stomachs at 14 localities but gave no indication of either the number of heteropods found or the number of stomachs examined. He reported the pteropod *Cavolina tridentata* from *T. albacares* stomachs at three localities.

Crustaceans were generally smaller than cephalopods and were usually consumed in larger numbers, particularly amphipods and larval forms. The number of the hyperiid amphipod *Phrosina semilunata* (lengths of 20-30 mm) per single stomach sometimes exceeded 100 and constituted a considerable portion of the forage volume. *Phrosina semilunata* was present in the stomachs of 65% of the *T. alalunga*, and in 20-30% of the other tuna species. Although not in large numbers, various species of the hyperiid genus *Phronima* were also frequently utilized. They were found in 15% of *T. albacares* and *T. thynnus*, and in 9% of *T. alalunga*. Several other species of hyperiid amphipods collectively showed a high frequency of occurrence (10-20% depending on species of tuna).

Decapods were the largest crustaceans consumed. Portunids, represented by the sargassum crab (*Portunus sayi*), when identifiable, were eaten by 11% of *T. albacares*. Brachyuran and anomuran larvae were found in about 10% of *T. albacares* and *T. alalunga*, though rarely present in *T. thynnus* and absent from *T. obesus*. The large penaeid larva *Cerataspis petiti* comprised a significant portion of the crustacean volume in 5% of *T. albacares* stomachs. Scyllarid larvae and juveniles were also consumed by *T. albacares* and *T. alalunga*, although less frequently. Other decapods, mostly larvae, occurred in low frequency when considered separately, but were present in a sizeable percentage of tuna stomachs (about 10-30%) when considered as a group.

Isopods and copepods were not significant in either volume or frequency (1-2%). In one sample, it appeared that copepods had been eaten by another forage organism and were in the tuna stomach only secondarily. Also, the isopod, *Cerathothoa* sp., a parasite of exocoetids, was probably ingested only incidentally, in the capture of its host.

***Alepisaurus*.**—Most of the invertebrates eaten by tunas were also consumed by *Alepisaurus* (Appendix Table 1). Forage composition differed, however, in the relative importance of different taxonomic groups. The percent-volume ratio of cephalopods:crustaceans was roughly 50:50 (Appendix Table 10). Crustaceans outranked cephalopods in frequency, however, in a ratio of 75:50. Deep-dwelling soft-bodied squids (Histioteuthidae, Bathyteuthidae, Cranchiidae; Roper and Young 1975) occurred more often in *Alepisaurus* (15%) than in any of the tunas. Other squids, although eaten less than by tunas, were still common (42%). Octopods were often present in *Alepisaurus* forage, *Argonauta* in 25%, *Alloposus* in 32%, and all others in 32% (Appendix Table 11).

Crustaceans were more often the exclusive content of an *Alepisaurus* stomach than were cephalopods. *Phronima* spp. (51%), other hyperiids (47%) (including two not found in the tunas), and anomuran larvae (22%) occurred in generally higher numbers and with higher frequency than in any of the tunas. No portunids were found in *Alepisaurus*, although two or three unidentified crab larvae were present.

Heteropods and pteropods were present in 14% and 12% of the *Alepisaurus* stomachs that we examined (Appendix Table 9) but the actual occurrence was much higher because Russell (1960) removed these mollusks from many of the *Alepisaurus* stomachs. Russell reported seven species of heteropods from three families and five species of pteropods from two families in his sample of *Alepisaurus* stomachs (Appendix Table 1). The heteropod *Carinaria lamarcki* and four species of the pteropod genus *Cavolina* were found at most stations, but Russell gave no numbers of forage organisms or of stomachs examined.

An important constituent of the *Alepisaurus* diet was the family of pelagic polychaetes, Alciopidae, present in 38% of the stomachs and forming much of the total food bulk. Gelatinous organisms (salps, pyrosomas, medusae, and siphonophores) were also more common in *Alepisaurus* stomachs than in tunas.

DISCUSSION

Planktonic and nektonic organisms comprising the diets of the tunas and lancetfishes ranged widely in size and form, suggesting that these predators feed opportunistically. Other data on the food of tunas show, worldwide, a large degree of consistency in forage composition, probably reflecting their association with a distinctive global epipelagic community (Haedrich and Nielsen 1966; Parin et al. 1969; Brodulina 1974). Fishes were consistently the largest and most frequently occurring taxonomic group and, where volumes were measured, constituted the largest forage volume. Cephalopods generally ranked second to fishes in all three measurements. Other invertebrates were generally much smaller but were often eaten in large numbers, particularly amphipods and larval crustaceans, probably encountered in swarms.

Despite such overall consistency, definite differences in the relative importance of certain forage categories do indicate some degree of feeding selectivity, either anatomical or behavioral. Some interspecific and intraspecific feeding differences can be traced to the anatomy of the predator. The size of the gill raker gap determines the minimum size of prey that can be captured and retained (Magnuson and Heitz 1971) and the maximum prey size is determined by the greatest distensibility of the predator's mouth and esophagus. Indeed, the small-mouthed tunas consumed generally smaller prey (mean forage fish length, 98 mm SL) than did the large-mouthed lancetfishes (mean forage fish length, 240 mm SL) .

A similar trend in forage utilization can be seen within a single tuna species. *Thunnus albacares* were divided into three size groups (60.0-99.9 cm FL, 100.0-119.9 cm FL, and 120.0-169.9 cm FL) to facilitate forage comparison. The largest fishes eaten (Gempylidae, $\bar{x}$ length 216 mm SL; Coryphaenidae, $\bar{x}$ length 141 mm SL; Alepisauridae, $\bar{x}$ length 120 mm SL; Paralepididae, $\bar{x}$ length 105 mm SL; Scombridae, $\bar{x}$ length 96 mm SL) were consumed most frequently by the largest sized tunas; among the prey families only the scombrids appeared in the smallest sized tunas. Conversely, the frequency of occurrence of the smallest forage organisms generally decreased with increasing tuna size, as shown by the overall mean frequency of occurrence for larval decapods in Appendix Table 6 ($\bar{x}$ 12.2% frequency of occurrence in 60.0-99.9 cm FL tunas; $\bar{x}$ 10.3% in 100.0-119.9 cm FL tunas; $\bar{x}$ 3.33% in 120.0-169.9 cm FL tunas). Similar trends were not apparent in the other tuna species (Appendix Tables 7-8).

A second limitation of forage composition is determined by the fish's predatory ability, particularly swimming speed. While the tunas are powerful, efficient swimmers, *Alepisaurus* is comparatively slow; this difference is reflected in the type of organism most frequently consumed. Swift-moving muscular squids (such as *Gonatus* and *Onychoteuthis*; Roper and Young 1975) were eaten much more frequently by tunas than by *Alepisaurus*; both capture squids more efficiently, however, than does the 10-foot Isaacs-Kidd midwater trawl. The predatory ability of tunas is further reflected in the frequency with which they consume such fast-swimming fishes as Belonidae, Scomberesocidae, Exocoetidae, Carangidae, and Coryphaenidae. The absence of these families from the *Alepisaurus* stomachs, however, may be due to the fact that they are found only near the surface, where *Alepisaurus* probably does not feed, rather than because *Alepisaurus* is unable to catch them.

Differences in depths at which predators feed probably constitute another mode of forage selectivity. In order to compare differences in feeding depth, we divided forage components somewhat arbitrarily into three categories according to their position in the water column: *Sargassum*-associates (strictly surface organisms associated with pelagic *Sargassum* in the upper 5 m of water); near-surface (the upper 20 m); and midwater (both vertical migrators and those which remain at depths).

Thunnus albacares evidently fed mainly at the surface, particularly on *Sargassum* associates. Bits of *Sargassum* present in stomachs were probably accidentally ingested in the process of capturing associated fauna, of which *Portunus sayi*, the sargassum crab, and large numbers of epipelagic decapod larvae were most frequently consumed (see Fig. 4). The most frequently occurring fishes in *T. albacares* stomachs were juveniles of reef and shore fishes, also associates of the *Sargassum* community.

The *Sargassum* community plays a similar role in the nutrition of other peak oceanic predators such as the dolphins *Coryphaena hippurus* and *C. equiselis* (Gibbs and Collette 1959). This utilization is reasonable to expect, as the *Sargassum* community provides the major concentration of forage organisms in the otherwise barren oceanic surface waters (see Fine 1970; Dooley 1972).

In contrast with the surface-oriented *T. albacares*, the diets of *T. alalunga*, *T. thynnus*, and *T. obesus*, composed mainly of midwater organisms, suggest that these tunas feed at somewhat greater depths. Forage compositions observed may be incomplete, however, because the samples examined were comparatively small.

The relatively small representation of epipelagic organisms and high frequency of occurrence of midwater fishes and invertebrates in the diet of *Alepisaurus* indicates that this predator feeds in the midwater layers (Figs. 3, 4). It might be noted in particular that *Alepisaurus* consumed the deeper-occurring gelatinous squids (Histioteuthidae, Bathyteuthidae, and Cranchiidae) and the gelatinous octopod, *Alloposus mollis* (family Alloposidae), much more frequently than did any of the tunas (except for *T. thynnus* feeding on *Alloposus mollis*). These cephalopods are probably not as abundant in the shallower levels, where tunas feed.

Relative feeding depths discussed above generally correspond to hooking depth records for tunas (Shomura and Murphy 1955; Yabe et al. 1963; Osipov 1968; Legand and Grandperrin 1973; Saito 1975) and lancetfishes. *Thunnus albacares* is generally the most shallow-occurring species; *T. alalunga* and *T. thynnus* occur

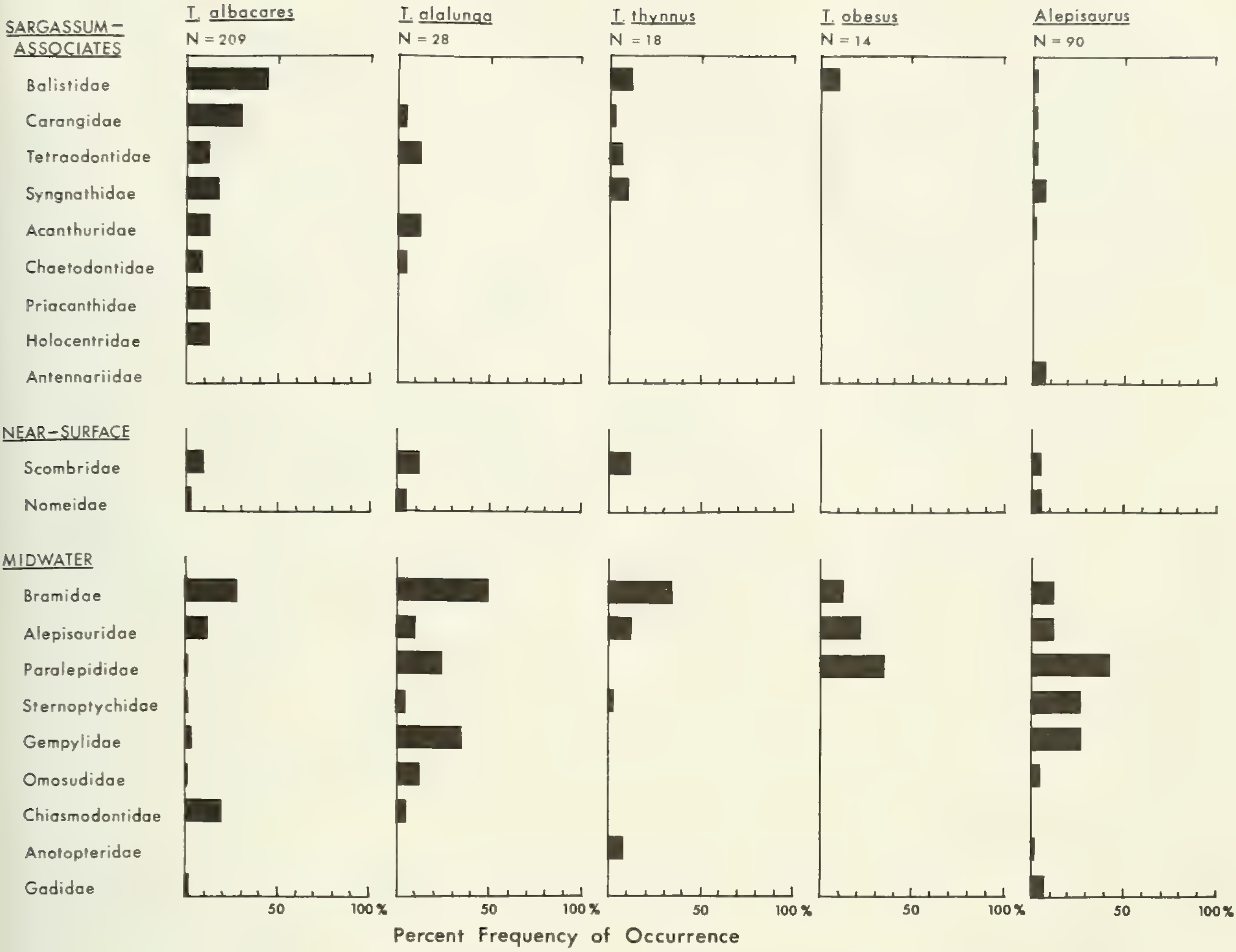

Figure 3.—Frequency of occurrence of the 20 most frequently occurring families of fishes in the stomachs of *Thunnus* and *Alepisaurus*. Families are separated into three categories: *Sargassum*-associates, near-surface, and midwater.

somewhat deeper and may have broader depth ranges; and *T. obesus* is recognized as the deepest swimming of the tunas. The distribution of the lancetfishes may be far broader than that of the tunas, although the lower depth limit is not established. Large specimens have been collected as shallow as 30 m, while small ones have been caught in open nets fished as deep as 2,000 m (Gibbs and Willimovsky 1966). Rancurel (1970) concluded that their primary feeding area is in the upper 300 m.

The following paragraphs summarize observations on forage composition reported in major studies from both the Atlantic and the Pacific for comparison with our data. Forage composition in these studies may reflect differences in the geographical distributions of prey, local abundances of forage organisms, or local differences in either predator or prey swimming depths but the taxonomic composition of the major food components is similar in all of these studies.

Thunnus albacares.—Dragovich (1970a) reported on the food of yellowfin from the western North Atlantic. *Auxis* sp. (Scombridae) constituted 26.6% of the food volume and occurred in 24.9% of the stomachs. Bramidae and Gempylidae occurred frequently and were moderately important in volume and Balistidae were common. Other surface organisms (Carangidae and Priacanthidae), which were common in our study, were surprisingly absent in the study by Dragovitch (1970a). Serranids occurred frequently, 53.8%, and constituted 56.9% of the total volume. Other high-ranking families in terms of occurrence and volume were Scombridae, Carangidae (mainly *Decapterus* sp.), Dactylopteridae (*Dactylopterus volitans*), and Chaetodontidae. Dragovich and Potthoff (1972) reported that the fish forage of yellowfins caught by live bait and trolling off the coast of West Africa consisted by occurrence and volume mainly of the epipelagic juveniles of Acanthuridae, Carangidae, Dactylopteridae, Lutjanidae, and Mullidae, and the midwater Gempylidae and Gonostomatidae.

In the diet of yellowfin tunas in the central Pacific, acanthurids and bramids, particularly *Collybus*

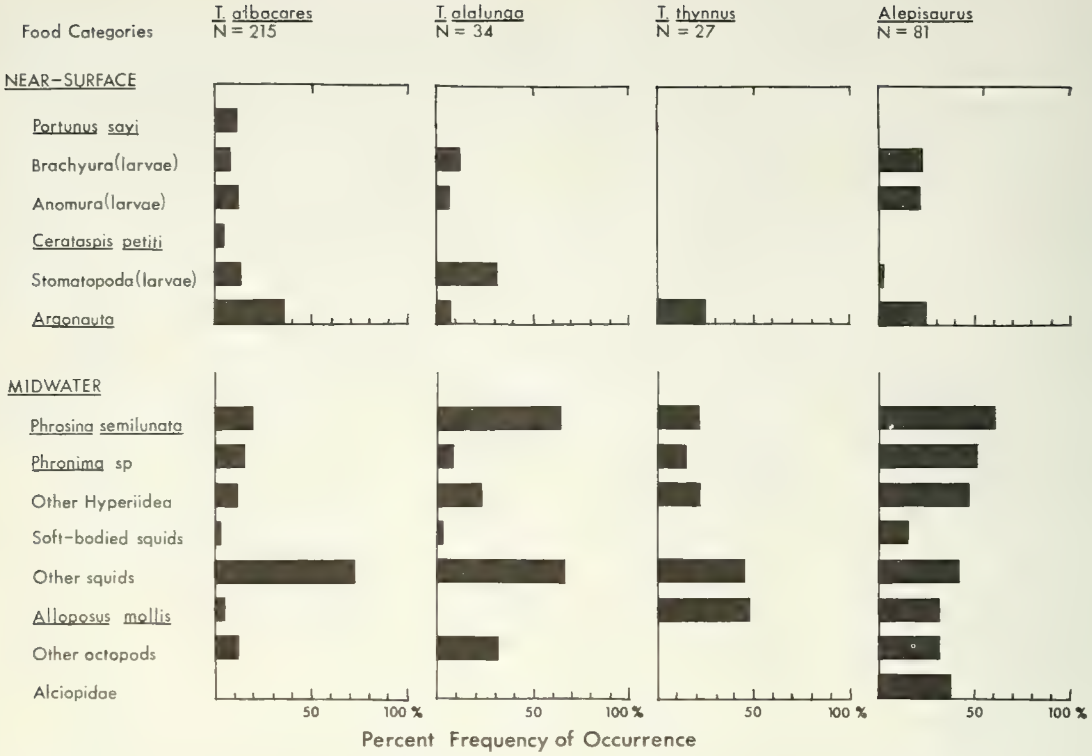

Figure 4.—Frequency of occurrence of invertebrate forage categories in the stomachs of *Thunnus* and *Alepisaurus*. Categories are separated by their general location in the water column: near-surface or midwater.

drachme, ranked high in number, volume, and frequency (Reintjes and King 1953). Exocoetids, scombrids (mainly *Katsuwonus pelamis*), and carangids (mainly *Decapterus* sp.) were important in volume, but were infrequently consumed. The most important fishes in the diet of central Pacific yellowfins were *Collybus drachme* and *Gempylus serpens* (King and Ikehara 1956). Scombridae and Mullidae were important in volume, though infrequently eaten. In the southwest Pacific, the families of fishes most frequently consumed by yellowfins were midwater Sternoptychidae (mostly *Argyropelecus* spp.), Paralepididae, and Bramidae, of which *Collybus drachme* was most important (Fourmanoir 1971). From the eastern tropical Pacific, Alverson (1963) reported Scombridae as the most important by volume (12.2%) followed in decreasing order of magnitude by Exocoetidae, Tetraodontidae, Carangidae, Myctophidae, and Serranidae.

Thunnus alalunga.—In stomachs of longline-caught albacore from the central and northeastern Pacific, the midwater families Gempylidae, Bramidae, Sternoptychidae, and Paralepididae were present most frequently (Iversen 1962). *Gempylus serpens* was the most frequently occurring species (9.9%) while *Collybus drachme* and *Sternoptyx* sp. were both present in 4.9% of the stomachs. In troll-caught albacore in California waters (Iversen 1971), however, the most important forage fishes in terms of both volume and frequency of occurrence were anchovies and sauries, with certain deeper-occurring fishes (*Tarletonbeania crenularis*, *Paralepis atlantica*, *Sebastes* spp.) occurring less frequently. Albacore from New Caledonia (Fourmanoir 1971) consumed Sternoptychidae, particularly *Sternoptyx diaphana*, and Bramidae, especially *Collybus drachme* most frequently.

Thunnus thynnus.—Dragovich (1970b) reported Bramidae (*Collybus drachme*) and the epipelagic Scombridae (particularly *Scomber scombrus* and *Auxis* sp.) and Syngnathidae (*Hippocampus erectus*) as the most frequently consumed fishes in western North Atlantic *T. t. thynnus*. In the stomachs of the northern Pacific bluefin, *T. thynnus orientalis*, however, Pinkas (1971) found that *Engraulis mordax* was the primary forage component (72.0% occurrence), followed by the red swimming crab, *Pleuroncodes planipes* (13.5% occurrence), and the saury, *Cololabis saira* (11.9% occurrence).

Thunnus obesus.—In her studies on the food of bigeye tuna from the Gulf of Guinea, Borodulina (1974) found midwater fishes, Paralepididae, Sternoptychidae, Gonostomatidae, Omosudidae, Scopelarchidae, and Alepisauridae most frequently consumed. Gempylidae and Diretmidae were only occasionally utilized, but occurred in large numbers when they were present. In the eastern tropical Atlantic, Gempylidae, Trichiuridae, Bramidae, Alepisauridae, and Myctophidae were most frequently utilized (Maksimov 1972). Northeast of Brazil, however, Maksimov found that shallower dwelling carangids and mackerels were frequently consumed, along with *Alepisaurus*.

Alepisaurus spp.—In the western North Atlantic, Haedrich (1964) reported findings similar to ours: paralipidids, sternoptychids, and alepisaurids were the most frequently occurring fishes. The midwater myctophids, gonostomatids, stomiatids, and chauliodontids that we observed, however, either occurred infrequently or were completely absent.

The most important food organisms in *Alepisaurus* from the Indian Ocean (Parin et al. 1969) were fishes of the families Sternoptychidae (*Sternoptyx diaphana*), Bramidae, Alepisauridae, Nomeidae, Paralepididae, and Gempylidae. Myctophidae, Gonostomatidae, and other fishes that make daily vertical migrations were missing. They suggsted that *Alepisaurus* feeds in the depths between the daytime and nighttime accumulation levels of migrating fishes, and passage of these interzonal populations may be quite rapid through the depths where the *Alepisaurus* were located, explaining the paucity of vertically migrating organisms.

In the southeastern Pacific, epipelagic fishes were more frequently eaten by *Alepisaurus* than midwater forms (Haedrich and Nielsen 1966), although some deeper living fishes such as *Dolichopteryx* were also occasionally present. *Alepisaurus* stomachs from Suruga Bay, Japan, contained fishes from surface, midwater, and bottom zones (Kubota and Uyeno 1969; Kubota 1973). The four dominant fishes in both studies were *Gephroberyx japonicus*, *Lophius litulon*, *Trichiurus lepturus*, and *Engraulis japonica*. In *Alepisaurus* from New Caledonia (Grandperrin and Legand 1970), the most frequently consumed fishes were *Diplospinus multistriatus* (30%) and *Sternoptyx diaphana* (24%). Cephalopods were present in 15% of the stomachs, crustaceans in 10%, and annelids in 12%, most often in young *Alepisaurus* specimens.

Most studies on tuna food have been limited either to qualitative analysis or to quantitative analysis based on a relatively small number of stomach samples from a limited area. The accumulation of such data has made evident the currently acknowledged opportunistic feeding pattern in tunas. A better understanding of interspecific differences in forage utilization might be met through large-scale quantitative analyses of tuna forage in comparison with in situ fauna and oceanographic conditions; there seems little need, however, for additional qualitative studies of tuna food in the future.

ACKNOWLEDGMENTS

We thank James L. Squire and Peter C. Wilson for permitting Gibbs and Collette to participate in longline cruises on the *Delaware* to collect tunas and stomach contents. Eugene L. Nakamura advised us on ways of analyzing the stomach contents. Ray S. Birdsong sorted some of the first fishes out of the stomach contents. Daniel M. Cohen, George C. Miller, William D. Anderson, Robert H. Gibbs, Jr., Arthur W. Kendall, Jr., David G. Smith, James C. Tyler, Theodore W. Pietsch, and others identified fishes. Thomas E. Bowman and Clyde Roper assisted in the identification of amphipods and cephalopods respectively. Keiko Hiratsuka Moore assisted with the figures and Terry L. Sayers typed the manuscript and tables. Alexander Dragovich offered useful suggestions during the preparation of this paper. Drafts of the manuscript were read by Daniel M. Cohen, Robert H. Gibbs, Jr., C. C. Lu, Eugene L. Nakamura, Thomas C. Potthoff, and Austin B. Williams.

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Appendix Table 1.—Forage components of *Thunnus* and *Alepisaurus*. (A) eaten by *Alepisaurus*; (T) eaten by *Thunnus*; (A*) addition to forage list of Haedrich (1964); (T*) addition to forage list of Dragovich (1969).

- Phylum Arthropoda
- Class Crustacea
  - Subclass Copepoda (T)
    - Order Calanoida
      - Family Aetideidae
        - *Euchirella* sp. (T*)
      - Family Candaciidae
        - *Candacia* sp. (T*)
  - Subclass Malacostraca
    - Order Isopoda (A) (T)
      - Suborder Flabellifera
        - Family Cirolanidae
          - *Cirolana* sp. (T*)
        - Family Cymothoidae
          - *Ceratothoa* sp. (T*)
      - Suborder Valvifera
        - Family Idoteidae
          - *Idotea* sp. (T)
    - Order Amphipoda
      - Suborder Hyperiidea (A) (T)
        - Family Lanceolidae
          - *Lanceola* sp. (A) (T)
        - Family Vibiliidae
          - *Vibilia* sp. (A*) (T)
        - Family Hyperiidae
          - *Hyperia galba* (A*) (T)
          - *Parathemisto gaudichaudii* (A*) (T)
        - Family Phronimidae
          - *Phronima* sp. (A) (T)
          - *Phronima atlantica* (incl. *solitaria*) (A) (T)
          - *Phronima sedentaria* (A) (T)
        - Family Phrosinidae
          - *Phrosina semilunata* (A) (T)
        - Family Lycaeidae
          - *Brachyscelus crusculum* (A) (T)
          - *Lycaea serrata* (A*)
        - Family Oxycephalidae
          - *Oxycephalus clausi* (A*)
        - Family Platyscelidae
          - *Platyscelus ovoides* (A) (T)
    - Order Stomatopoda (larva) (T)
          - *Lysiosquilla* (larva) (A*) (T)
    - Order Euphausiacea (A) (T)
          - *Meganyctiphanes norvegica* (A*) (T)
    - Order Decapoda (larva and adult) (A) (T)
      - Superfamily Penaeidea (A*) (T)
          - *Cerataspis petiti* (larva) (T)
      - Superfamily Caridea (larva) (A*) (T); (adult) (T)
          - *Hippolyte zostericola* (T*)
          - *Notostomus* sp. (T*)
          - *Periclimenes* (*Harpilius*) *americanus*? (T*)
        - Family Scyllaridae (larva) (A) (T)
          - *Scyllarides* sp. (T)
          - *Scyllarus* sp. (A*) (T)
      - Superfamily Nephropsidea (larva) (T)
      - Section Anomura (larva) (T)
        - Family Diogenidae (larva) (A*) (T)
          - *Paguristes* ? (larva) (A*) (T)
      - Section Dromiacea (larva) (A*) (T)
      - Section Brachyura (larva) (A) (T); (adult) (T)
        - Family Portunidae (T)
          - *Portunus sayi* (T*)

- Phylum Mollusca
- Class Gastropoda (A) (T)
    - Order Heteropoda (A) (T)
        - Family Atlantidae
          - *Atlanta peronii* (A)
          - *Oxygyrus keraudrenii* (A)
        - Family Carinariidae
          - *Carinaria lamarcki* (A) (T)
          - *Cardiapoda placenta* (A)
        - Family Pterotracheidae
          - *Pterotrachea hippocampus* (A)
          - *Pterotrachea scutata* (A)
          - *Pterotrachea coronata* (A)
    - Order Pteropoda (A) (T)
        - Family Cavoliniidae
          - *Cavolina tridentata* (A) (T)
          - *Cavolina uncinata* (A)
          - *Cavolina gibbosa* (A)
          - *Cavolina trispinosa* (A)
        - Family Pneumodermatidae
          - *Pneumoderma atlanticum* (A)
    - Order Nudibranchia
        - Family Phylliroidae
          - *Phyllirhoe* sp. (A*)
- Class Cephalopoda (A) (T)
    - Order Teuthoidea
      - Suborder Oegopsida (A) (T)
        - Family Gonatidae (T)
          - *Gonatus fabricii* (T)
        - Family Enoploteuthidae (T)
          - *Abraliopsis* sp. (A)
          - *Enoploteuthis* sp. (A*) (T*)
          - *Enoploteuthis anapsis* (A*)
          - *Pterygioteuthis giardi* (A*)
        - Family Onychoteuthidae (A) (T)
          - *Onychoteuthis* sp. (T)
          - *Onykia* ? sp. (T)
        - Family Lepidoteuthidae (T)
          - *Tetronychoteuthis dussumieri* (T*)
        - Family Brachioteuthidae (A*) (T)
          - *Brachioteuthis riisei* (A*) (T)
        - Family Histioteuthidae (A*) (T)
          - *Histioteuthis* sp. (T)
          - *Histioteuthis elongata* (A*)
        - Family Bathyteuthidae (A)
          - *Bathyteuthis abyssicola* (A*)
        - Family Ommastrephidae (A) (T)
          - *Hyaloteuthis pelagica* (T*)
          - *Illex* sp. (A*) (T)
          - *Ommastrephes* spp. (A*) (T)
          - *Ommastrephes caroli* (T*)
          - *Ornithoteuthis antillarum* (T*)
        - Family Thysanoteuthidae (T)
          - *Thysanoteuthis rhombus* (T*)
        - Family Cranchiidae (A) (T)
          - *Cranchia scabra* (T)
          - *Leachia* sp. (A*) (T*)
          - *Megalocranchia* ? sp. (A)
    - Order Octopoda (A) (T)
        - Family Bolitaenidae
          - *Eledonella pygmaea* (A*) (T*)
        - Family Alloposidae
          - *Alloposus mollis* (A*) (T)
        - Family Ocythoidae
          - *Ocythoe tuberculata* (T)
        - Family Octopodidae
          - *Octopus* sp. (A*) (T)
          - *Danoctopus schmidti* (A*)
          - *Scaeurgus unicirrhus* (A*) (T*)
        - Family Argonautidae
          - *Argonauta* sp. (A) (T)
          - *Argonauta argo* (A) (T*)

- Phylum Coelenterata
- Class Scyphozoa (Medusae) (A) (T)

Appendix Table 1.—Forage components of *Thunnus* and *Alepisaurus*. (A) eaten by *Alepisaurus*; (T) eaten by *Thunnus*; (A*) addition to forage list of Haedrich (1964); (T*) addition to forage list of Dragovich (1969).—Continued.

- Class Hydrozoa
  - Order Siphonophora (A*)

- Phylum Annelida
- Class Polychaeta
  - Family Alciopidae
    - *Greeffia* sp. (A*)
    - *Vanadis* sp. (A*)

- Phylum Chordata
  - Subphylum Tunicata
    - Salpida (A) (T)
- Class Osteichthyes
  - Order Anguilliformes
    - Family Muraenidae
      - *Uropterygius diophus* (A*)
    - Family Ophichthidae
      - *Myrophis punctatus* (T*)
      - *Pisodonophis cruentifer* (A*)
    - Family Nemichthyidae (T)
      - *Nemichthys scolopaceus* (T)
  - Order Clupeiformes
    - Family Clupeidae (T)
  - Order Salmoniformes
    - Family Argentinidae (A)
    - Family Gonostomatidae (A) (T)
      - *Gonostoma* sp. (A) (T)
      - *Maurolicus* sp. (T)
    - Family Sternoptychidae (A) (T)
      - *Argyropelecus aculeatus* (A) (T)
      - *Sternoptyx diaphana* (A) (T)
    - Family Stomiatidae (T)
      - *Eustomias* sp. (T*)
    - Family Aulopidae (T)
      - *Aulopus nanae* (T*)
    - Family Paralepididae (A) (T)
      - *Lestidiops* sp. (T*)
      - *Lestidiops affinis* (A)
      - *Lestidium atlanticum* (A) (T*)
      - *Macroparalepis* sp. (A)
      - *Notolepis rissoi* (T)
      - *Paralepis* sp. (T)
      - *Paralepis atlantica* (A)
      - *Paralepis coregonoides* (A) (T)
      - *Paralepis elongata* (A) (T*)
      - *Stemonosudis* sp. (T*)
    - Family Omosudidae (A) (T)
      - *Omosudis lowei* (A) (T)
    - Family Alepisauridae (A) (T)
      - *Alepisaurus* sp. (A) (T)
      - *Alepisaurus brevirostris* (A) (T*)
      - *Alepisaurus ferox* (A) (T)
    - Family Anotopteridae (A) (T)
      - *Anotopterus pharao* (A) (T)
    - Family Myctophidae (A) (T)
      - *Gonichthys coccoi* (T*)
      - *Lampanyctus* sp. (A)
  - Order Lophiiformes
    - Family Lophiidae (A)
      - *Lophius americanus* (A)
    - Family Antennariidae (A) (T)
      - *Antennarius radiosus* (A) (T)
    - Family Ogcocephalidae (A) (T)
      - *Dibranchus atlanticus* (T*)
      - *Halieutichthys aculeatus* (A)
    - Suborder Ceratioidei
      - Family Ceratiidae
        - *Borophryne* sp. (T*)
      - Family Linophrynidae (T*) (A)
        - *Linophryne* sp. (T*) (A)
  - Order Gadiformes
    - Family Moridae
      - *Laemonema barbatula* (A*)
    - Family Bregmacerotidae (A)
      - *Bregmaceros* sp. (A)
    - Family Gadidae (A) (T)
      - *Melanogrammus aeglefinus* (A) (T*)
      - *Merluccius bilinearis* (T)
  - Order Atheriniformes
    - Family Belonidae (T)
      - *Tylosurus acus* (T*)
    - Family Scomberesocidae (T)
      - *Scomberesox saurus* (T)
    - Family Exocoetidae (T)
      - *Cypselurus* sp. (T)
      - *Cypselurus heterurus* (T)
      - *Exocoetus obtusirostris* (T)
    - Family Hemiramphidae
      - *Hyporhamphus* sp. (T)
  - Order Beryciformes
    - Family Melamphaidae (T*)
    - Family Anoplogasteridae (A) (T)
      - *Anoplogaster cornutus* (A) (T)
    - Family Monocentridae (T*)
    - Family Holocentridae (T)
      - *Holocentrus* sp. (T)
      - *Holocentrus ascensionis* (T)
  - Order Zeiformes
    - Family Caproidae (T)
      - *Antigonia capros* (T)
      - *Capros aper* (T)
  - Order Lampridiformes
    - Family Lophotidae (T*)
    - Family Trachipteridae (A) (T)
      - *Trachipterus* sp. (A) (T)
  - Order Gasterosteiformes
    - Family Fistulariidae (T)
      - *Fistularia* sp. (T)
    - Family Syngnathidae (A) (T)
      - *Hippocampus* sp. (T)
      - *Hippocampus erectus* (A) (T*)
  - Order Scorpaeniformes
    - Family Scorpaenidae (A)
    - Family Triglidae
      - *Peristedion gracile* (T)
      - *Peristedion greyae* ? (T)
      - *Peristedion miniatum* (T)
  - Order Dactylopteriformes
    - Family Dactylopteridae (T)
      - *Dactylopterus volitans* (T)
  - Order Perciformes
    - Family Serranidae (A) (T)
      - *Serranus* sp. (T*)
    - Family Priacanthidae (T)
      - *Cookeolus boops* (T*)
      - *Pseudopriacanthus* sp. (T)
    - Family Echeneidae (T)
      - *Remora osteochir* (T*)
    - Family Carangidae (T)
      - *Caranx* sp. (T)
      - *Selar crumenophthalmus* (T)
      - *Seriola dumerili* (T*)
      - *Seriola rivoliana* (T*)
      - *Trachurus* sp. (T)
      - *Trachurus lathami* (T)
      - *Vomer setapinnis* (T)
    - Family Coryphaenidae (T)
      - *Coryphaena equiselis* (T*)
      - *Coryphaena hippurus* (T)

Appendix Table 1.—Forage components of *Thunnus* and *Alepisaurus*. (A) eaten by *Alepisaurus*; (T) eaten by *Thunnus*; (A*) addition to forage list of Haedrich (1964); (T*) addition to forage list of Dragovich (1969).—Continued.

    - Family Bramidae (T)
      - *Collybus drachme* (T)
      - *Pteraclis* sp. (A) (T)
      - *Pterycombus* sp. (A) (T)
      - *Taractes* sp. (T)
    - Family Lutjanidae (A) (T)
      - *Pristipomoides* sp. (A) (T)
      - *Pristipomoides aquilonurus* (T)
    - Family Chaetodontidae (T)
      - *Centropyge argi* (T*)
    - Family Pomacentridae (T*)
    - Family Trichodontidae (T*)
    - Family Uranoscopidae (A)
      - *Kathestoma averruncus* (A)
    - Family Chiasmodontidae (T)
      - *Pseudoscopelus* sp. (T*)
    - Family Acanthuridae (A) (T)
      - *Acanthurus chirurgus* (T)
      - *Acanthurus coeruleus* (T)
  - Suborder Scombroidei (A) (T)
    - Family Gempylidae (A) (T)
      - *Diplospinus multistriatus* (A) (T*)
      - *Gempylus serpens* (T)
      - *Nealotus* sp. (A)
      - *Nealotus tripes* (A) (T*)
      - *Nesiarchus nasutus* (A) (T)
    - Family Trichiuridae (T)
    - Family Scombridae (A) (T)
      - *Auxis* sp. (A) (T)
      - *Euthynnus alletteratus* (T)
      - *Katsuwonus pelamis* (T)
      - *Scomber japonicus* (A*) (T)
      - *Thunnus atlanticus* (T)
    - Family Xiphiidae
      - *Xiphias gladius* (T*)
  - Suborder Stromateoidei (A) (T)
    - Family Stromateidae (A)
      - *Peprilus triacanthus* (A)
    - Family Centrolophidae (A) (T)
      - *Hyperglyphe* sp. (T*)
      - *Hyperglyphe perciformis* (A) (T)
    - Family Nomeidae (A) (T)
      - *Nomeus* sp. (A) (T)
      - *Psenes maculatus* (T*)
      - *Psenes pellucidus* (A) (T*)
    - Family Tetragonuridae (A) (T)
      - *Tetragonurus cuvieri* (A) (T)
- Order Pleuronectiformes
    - Family Bothidae (A) (T)
- Order Tetraodontiformes
  - Suborder Balistoidei (T)
    - Family Balistidae (incl. Monacanthidae) (A) (T)
      - *Aluterus* sp. (T)
      - *Balistes* sp. (T)
      - *Balistes capriscus* (T)
      - *Cantherhines* sp. (T)
      - *Canthidermis* sp. (T)
      - *Canthidermis maculatus* (T*)
      - *Monacanthus* sp. (T*)
      - *Monacanthus ciliatus* (T)
      - *Monacanthus hispidus* (T*)
      - *Monacanthus tuckeri* (A) (T)
      - *Xanthichthys ringens* (T)
    - Family Tetraodontidae (A) (T)
      - *Lagocephalus* sp. (T)
      - *Sphoeroides* sp. (T)
    - Family Diodontidae (T)
      - *Chilomycterus* sp. (T*)
      - *Diodon* sp. (T)
    - Family Molidae (T)
      - *Mola mola* (T*)
      - *Ranzania laevis* (T*)

Appendix Table 2.—Precent frequency of occurrence of food fish categories identified from 266 stomachs of western North Atlantic *Thunnus albacares* by size range.

Food fish categories	Size (cm FL):	60.0-99.9	100.0-119.9	120.0-169.9	Unknown	Total
	No. of specimens:	58	90	63	55	266
Sternoptychidae (unid.)					3	< 1
Sternoptyx diaphana			1			< 1
Aulopidae						
Aulopus nanae			1			< 1
Paralepididae (unid.)			1	5		2
Omosudidae						
Omosudis lowei					2	< 1
Alepisauridae						
Alepisaurus brevirostris				3		1
A. ferox				2		< 1
Ogcocephalidae (unid.)		3	1	4		2
Halieutichthys aculeatus					2	< 1
Ceratioidei (unid.)			1			< 1
Ceratiidae						
Borophryne sp.					2	< 1
Gadidae						
Melanogrammus aeglefinus			1			< 1
Belonidae						
Tylosurus acus		2				< 1
Exocoetidae					4	1
Cypselurus sp.					2	< 1
C. heterurus					2	< 1
Exocoetus obtusirostris					2	< 1
Hemiramphidae						
Hyporhamphus sp.					2	< 1
Scomberesocidae						
Scomberesox saurus			2	2		1
Anoplogasteridae						
Anoplogaster cornutus		2			4	1
Holocentridae (unid.)			13	8		6
Holocentrus sp.			2			1
H. ascensionis					2	< 1
Caproidae						
Antigonia capros		3				1
Fistulariidae						
Fistularia sp.					2	< 1
Syngnathidae (unid.)			4	2		2
Hippocampus sp.		5	6	11	2	6
H. erectus		2	2	14		5
Triglidae						
Peristedion greyae			1		1	1
P. gracile			1			< 1
P. miniatum				2		< 1
Dactylopteridae						
Dactylopterus volitans			2	2		1
Perciformes (unid.)		2				< 1
Serranidae (unid.)		2	1			1
Priacanthidae						
Cookeolus boops		16	10	5		9
Pseudopriacanthus sp.					3	< 1
Echeneidae						
Remora osteochir		3				1
Carangidae (unid.)		5	7	3		4
Caranx sp.		7	20	11		11
Selar crumenophthalmus		5	2			2
Seriola dumerili					2	< 1
S. falcata					4	1
Trachurus sp.		7	2			2
Vomer setapinnis		3	6	6		4

Appendix Table 2.—Percent frequency of occurrence of food fish categories identified from 266 stomachs of western North Atlantic *Thunnus albacares* by size range.—Continued.

Food fish categories	Size (cm FL): No. of specimens:	60.0-99.9 58	100.0-119.9 90	120.0-169.9 63	Unknown 55	Total 266
Coryphaenidae						
Coryphaena equiselis				3	2	1
Coryphaena hippurus		2	6	6	4	5
Bramidae (unid.)		3	1	2		2
Collybus drachme		5	2	6		3
Pteraclis sp.					4	1
Pterycombus sp.		26	13	3		11
Taractes sp.					3	< 1
Lutjanidae						
Pristipomoides sp.			1			< 1
Chaetodontidae (unid.)		10	1	2		3
Centropyge argi		5	1	2		2
Chiasmodontidae (unid.)					11	2
Pseudoscopelus sp.		16	11	3		8
Acanthuridae (unid.)		9	7	2		5
Acanthurus coeruleus					4	1
Acanthurus chirurgus					2	< 1
Trichiuridae (unid.)			1			< 1
Gempylidae (unid.)				2		< 1
Diplospinus multistriatus					6	2
Gempylus serpens					3	1
Nealotus tripes					3	1
Neasiarchus nasutus					2	< 1
Scombridae						
Auxis sp.		5	3	8	7	5
Euthynnus alletteratus				2		< 1
Katsuwonus pelamis		2	4			2
Thunnus atlanticus				2		< 1
Xiphiidae						
Xiphias gladius				2		< 1
Stromateoidei (unid.)			2	2		2
Nomeidae (unid.)		2	1			1
Tetragonuridae						
Tetragonurus cuvieri			1			< 1
Bothidae (unid.)		2				< 1
Tetraodontiformes (unid.)		3	3			2
Balistoidei (unid.)			3	3		2
Balistidae (including Monacanthidae)		19	24	27	3	12
Aluterus sp.				3	5	2
Balistes sp.			1	10	3	3
Balistes capriscus		2	2		9	3
Cantherhines sp.				2		< 1
Canthidermis sp.		5	1			2
Canthidermis maculatus		2				< 1
Monacanthus sp.			6	17	5	7
Monacanthus ciliatus				2		< 1
Monacanthus hispidus					3	< 1
Xanthichthys ringens			2	3		2
Tetraodontidae (unid.)		5	2			2
Lagocephalus sp.				5	4	2
Sphoeroides sp.		3	8			3
Diodontidae						
Diodon sp.		2	2	3	2	2
Molidae (unid.)		2				< 1
Mola mola				2		< 1
Ranzania laevis		2	6		2	3
Unidentified fishes		21	17	25	67	30

Appendix Table 3.—Percent frequency of occurrence of food fish categories in 38 stomachs of western North Atlantic *Thunnus alalunga* by size range.

	Size (cm FL):	80.0-99.9	100.0-110.0	Unknown	Total
Food fish categories	No. of specimens:	13	15	10	38
Sternoptychidae					
Sternoptyx diaphana			7		3
Paralepididae (unid.)			7	30	11
Omosudidae					
Omosudis lowei				20	5
Alepisauridae				20	5
Myctophidae				10	3
Ogcocephalidae (unid.)		8			3
Caproidae					
Antigonia capros				10	3
Triglidae					
Peristedion gracile		8			3
Perciformes (unid.)		8			3
Serranidae (unid.)			7		3
Carangidae					
Vomer setapinnis			7		3
Bramidae					
Collybus drachme				10	3
Pteraclis sp.				30	8
Pterycombus sp.			23		8
Chaetodontidae (unid.)		8			3
Pomacentridae (unid.)				10	3
Chiasmodontidae				10	3
Acanthuridae				20	5
Gempylidae				10	3
Diplospinus multistriatus				30	8
Nealotus tripes				10	3
Nesiarchus nasutus				10	3
Scombridae					
Auxis sp.		15			5
Scomber japonicus		8			3
Nomeidae					
Psenes pellucidus			7		3
Bothidae		8			3
Tetraodontidae		8		10	5
Diodontidae					
Chilomycterus sp.			7		3
Unidentified fishes		77	67	40	63

Appendix Table 4.—Percent frequency of occurrence of food fish categories in 38 stomachs of western North Atlantic *Thunnus thynnus*.

Food fish categories	% freq.
Ophichthidae	
Myrophis punctatus	3
Sternoptychidae	
Argyropelecus aculeatus	3
Alepisauridae	
Alepisaurus sp.	8
Anotopteridae	
Anotopterus pharao	5
Scomberesocidae	
Scomberesox saurus	5
Anoplogasteridae	
Anoplogaster cornutus	5
Lophotidae	3
Syngnathidae	
Hippocampus erectus	8
Carangidae	3
Bramidae	
Collybus drachme	8
Pteraclis sp.	5
Taractes sp.	8
Trichiuridae	3
Scombridae	
Auxis sp.	8
Balistidae (incl. Monacanthidae)	
Aluterus sp.	3
Monacanthus hispidus	5
Xanthichthys ringens	3
Tetraodontidae	
Sphoeroides sp.	5
Diodontidae	5
Molidae	
Mola mola	6
Unidentified fishes	37

Appendix Table 5.—Percent frequency of occurrence of food fish categories in 81 stomachs of western North Atlantic *Alepisaurus*.

Food fish categories	% freq.
Ophichthidae	
Pisodonophis cruentifer	1
Muraenidae	
Uropterygius diopus	1
Argentinidae	1
Gonostomatidae	
Gonostoma sp.	1
Sternoptychidae	
Argyropelecus aculeatus	2
Sternoptyx diaphana	25
Aulopidae	
Aulopus nanae	2
Paralepididae	5
Lestidium affine	1
Lestidium atlanticus	1
Macroparalepis sp.	4
Notolepis rissoi	5
Paralepis sp.	6
Paralepis brevirostris	4
Paralepis coregonoides	33
Paralepis elongata	4
Omosudidae	2
Omosudis lowei	1
Alepisauridae	
Alepisaurus sp.	4
Alepisaurus brevirostris	5
Alepisaurus ferox	4
Anotopteridae	
Anotopterus pharao	1
Myctophidae	
Lampanyctus sp.	1
Lophiidae	
Lophius americanus	1
Antennariidae	
Antennarius radiosus	6
Ogcocephalidae	1
Halieutichthys aculeatus	2
Linophrynidae	
Linophryne sp.	2
Bregmacerotidae	
Bregmaceros sp.	1
Gadidae	
Melanogrammus aeglefinus	5
Moridae	
Laemonema barbatula	4
Anoplogasteridae	
Anoplogaster cornutus	2
Trachipteridae	
Trachipterus sp.	1
Syngnathidae	
Hippocampus erectus	6
Scorpaenidae	2
Serranidae	2
Carangidae	
Trachurus lathami	1
Vomer setapinnis	1
Bramidae	2
Pteraclis sp.	4
Pterycombus sp.	5
Lutjanidae	1
Pristipomoides sp.	1
Uranoscopidae	
Kathestoma averruncus	1
Acanthuridae	1
Gempylidae	1
Diplospinus multistriatus	14
Neolotus sp.	1
Neolotus tripes	7
Nesiarchus nasutus	5
Scombridae	
Auxis sp.	1
Scomber japonicus	2
Stromateidae	2
Peprilus triacanthus	1
Centrolophidae	
Hyperglyphe perciformis	4
Nomeidae	
Nomeus sp.	2
Psenes pellucidus	2
Tetragonuridae	
Tetragonurus cuvieri	1
Bothidae	2
Balistidae	1
Monacanthus tuckeri	1
Tetraodontidae	2

Appendix Table 6.—Percent frequency of occurrence of principal invertebrate groups in 215 stomachs of western North Atlantic *Thunnus albacares* by size range.

	Size (cm FL):	60.0-99.9	100.0-119.9	120.0-169.9	Total
Food categories	No. of specimens:	59	91	65	215
Portunidae		12	7	15	11
Brachyura larvae		8	10	5	8
Anomura larvae		19	14	2	12
Cerataspis larvae		5	7	3	5
Scyllaridae (incl. larvae)			3	2	2
Other Decapoda (incl. larvae)		12	8	5	8
Stomatopoda larvae		17	20	3	14
Euphausiacea		5			1
Phrosina semilunata		29	16	17	20
Phronima spp.		12	15	17	15
Other Hyperiidea		15	9	11	11
Isopoda		2	3		2
Copepoda		2	2	3	2
Heteropoda		10	10	11	10
Pteropoda					< 1
Other Gastropoda		3			
Cephalopoda		83	77	82	80

Appendix Table 7.—Percent frequency of occurrence of principal invertebrate groups in 34 stomachs of western North Atlantic *Thunnus alalunga* by size range.

	Size (cm FL):	80.0-99.9	100.0-110	Total
Food categories	No. of specimens:	15	19	34
Brachyura larvae		20	5	12
Anomura larvae		13		6
Scyllaridae (incl. larvae)		7	11	9
Other Decapoda (incl. larvae)		20	37	29
Stomatopoda larvae		13	47	32
Euphausiacea		7	11	9
Phrosina semilunata		60	68	65
Phronima spp.		7	10	9
Other Hyperiidea		20	26	24
Cephalopoda		93	84	89

Appendix Table 8.—Percent frequency of occurrence of principal invertebrate groups in 27 stomachs of western North Atlantic *Thunnus thynnus* by size range.

	Size (cm FL):	100.0-149.9	150.0-199.9	200.0-231.9	Total
Food categories	No. of specimens:	10	10	7	27
Other Decapoda (incl. larvae)			20	14	11
Euphausiacea		10	10	14	11
Phrosina semilunata			50	14	22
Phronima spp.		10	30		15
Other Hyperiidea		10	40	14	22
Heteropoda; Pteropoda		70	50	29	52
Cephalopoda		90	90	71	85

Appendix Table 9.—Percent frequency of occurrence of principal invertebrate groups in 81 stomachs of western North Atlantic *Alepisaurus* spp.

Food categories	% freq.
Brachyura larvae	23
Anomura larvae	22
Scyllaridae (larvae)	5
Other Decapoda (incl. larvae)	4
Stomatopoda larvae	2
Euphausiacea	17
Phrosina semilunata	60
Phronima spp.	51
Other Hyperiidea	47
Isopoda	1
All Crustacea combined	75
Heteropoda	14
Pteropoda	12
Other Gastropoda	4
Polychaeta	38
Salpa and Pyrosoma	16
Cephalopoda	49
Medusae	6

Appendix Table 10.—Occurrence and co-occurrence of crustaceans and cephalopods in the stomachs of western North Atlantic *Thunnus* and *Alepisaurus* species.

	Number of exclusive occurrences		Number of co-occurrences	Co-occurrence, estimated average percent-volume	
Species	Crustaceans	Cephalopods		Crustaceans	Cephalopods
T. albacares	28	89	125	31	69
T. alalunga	7	8	30	33	67
T. obesus	1	7	7	21	79
T. thynnus	3	26	14	23	77
Alepisaurus spp.	30	9	31	54	46

Appendix Table 11.—Percent frequency of occurrence of cephalopod groups in stomachs of western North Atlantic *Thunnus* and *Alepisaurus* species.

	T. albacares	*T. alalunga*	*T. obesus*	*T. thynnus*	*Alepisaurus* spp.
Specimens containing cephalopods (Percent of total)	214 (77)	38 (79)	14 (100)	40 (77)	40 (49)
Soft-bodied squids,[1] % with	2	3	0	0	15
Other squids, % with	72	66	86	45	42
Argonauta spp., % with	36	8	0	25	25
Alloposus mollis, % with	5	0	0	48	32
Other octopods, % with	12	32	0	0	32

[1] Bathyteuthidae, Cranchiidae, and Histioteuthidae.

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Doyle F. Sutherland

March 1977

U.S. DEPARTMENT OF COMMERCE
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NOAA Technical Report NMFS SSRF-708

Catch and Catch Rates of Fishes Caught by Anglers in the St. Andrew Bay System, Florida, and Adjacent Coastal Waters, 1973

Doyle F. Sutherland

March 1977

U.S. DEPARTMENT OF COMMERCE
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Catch and Catch Rates of Fishes Caught by Anglers in the St. Andrew Bay System, Florida, and Adjacent Coastal Waters, 1973

DOYLE F. SUTHERLAND[1]

ABSTRACT

Anglers were interviewed on four fixed platforms in the St. Andrew Bay system and on charter boats that were fishing in the bay and adjacent coastal waters in 1973. They caught fishes of at least 54 species (not all were identified to species) in 31 families. The majority (58.0%) of the fishes that were caught from fixed platforms consisted of pinfish, *Lagodon rhomboides*, (18.2%); sea catfish, *Arius felis*, (12.2%); spotted seatrout, *Cynoscion nebulosus*, (10.0%); blue runner, *Caranx crysos*, (8.8%); and crevalle jack, *Caranx hippos*, (8.8%). On charter boats, king mackerel, *Scomberomorus cavalla*, comprised the majority of the catches (73.9%).

The average catch rates varied from 0.0 to 10.7 fish/h among anglers on fixed platforms and from 0.0 to 32.0 fish/h among charter boats. The greatest monthly average catch rates on fixed platforms were 2.2 fish/h in October at Deer Point Dam, 1.8 in October at Bailey Bridge, 1.8 in December at Hathaway Bridge, 2.3 in May at West Jetty, and 10.6 in September on charter boats. On the fixed platforms, the highest average catch rate for all months was 1.4 with squid and the lowest was 0.5 with fiddler crabs. Whole round scads and 00-squid spoons were used for bait by virtually all surveyed charter boats.

INTRODUCTION

The St. Andrew Bay system and adjacent coastal waters (Fig. 1) attract many recreational anglers. The recreational fishery has not been previously assessed. A 1973 catch and catch rate survey of recreational fishing in the area was conducted to provide fishery managers with baseline estimates of fish availability to anglers for evaluating future trends. A companion study of the commercial and recreational fishing effort for fisheries in the area was also conducted in 1973 (Sutherland, manuscript in preparation).

Increased demand for food and sport fishes is a growing concern to fishery managers. In recent years, the landings in pounds of food fishes by anglers have amounted to about one-half the commercial landings (Deuel 1973; U.S. Department of Commerce 1976). In the eastern Gulf of Mexico, croakers exceeded all other species in numbers caught, followed by spotted seatrout, catfishes, sand seatrout, porgies, kingfishes, and grunts (Deuel 1973). Croakers and seatrouts are highly regarded by the public and are readily available to commercial and recreational fishermen in estuarine habitats. The number of recreational fishermen seeking those and other fishes is estimated to increase by 8-10% annually (Deuel 1973). The number of commercial fishermen is presumably limited by finfish availability and by social and economic factors that prevail in the area.

A relatively nonrestricted commercial fishery for shrimp and for food and bait fishes exists in the St. Andrew Bay system and adjacent coastal waters. A daily bag and size limit on several species of fishes is imposed on recreational anglers.

Catch and effort data for commercial and recreational fishing in identifiable management areas are needed to achieve optimum biological yield and to resolve other resource management problems (Irby 1974). While commercial landings are documented annually, the information is of little value for management of identifiable areas, for the fishing location and fishing effort are omitted. Similarly, catch and catch rates obtained from anglers may or may not reflect the actual availability or abundance of fishes, for angling success depends on such factors as angling skill, method, bait, location, etc. Not

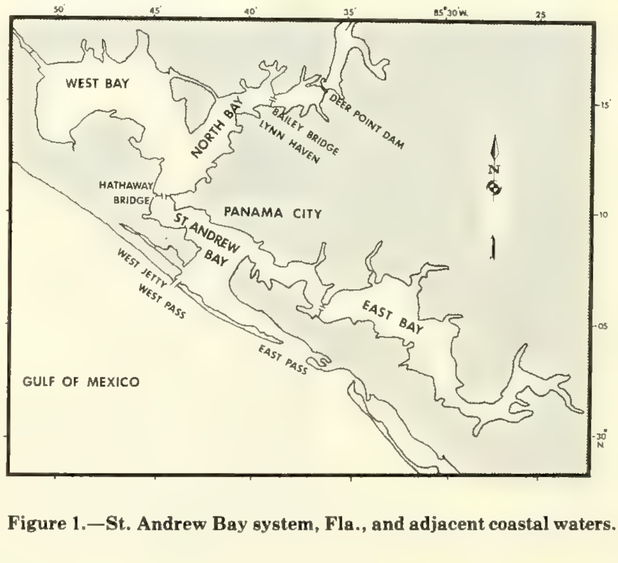

Figure 1.—St. Andrew Bay system, Fla., and adjacent coastal waters.

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all species of food or game fishes known to occur in St. Andrew Bay were caught by the interviewed anglers. The red snapper, *Lutjanus campechanus*, and tarpon, *Megalops atlantica*, are examples. The results from our catch and catch rate survey are presented below.

METHODS

Anglers on four fixed platforms in the St. Andrew Bay system and charter boat captains or mates who fished in the bay, inlet, and adjacent coastal waters (Fig. 1) were interviewed for catch rate data. The fixed platforms were: 1) Deer Point Dam, 2) Bailey Bridge, 3) Hathaway Bridge, and 4) West Jetty. Only charter boatmen that trolled for nearshore pelagic fishes, chiefly Spanish and king mackerels, were interviewed, since charter boats in the demersal fishery generally fish beyond 25 km offshore. More importantly, charter boatmen are exceedingly reluctant to reveal the location of their demersal fishing grounds. Most of the interviewed charter boatmen fished within 25 km of West Pass.

The creel census was conducted twice weekly by rotating the visits among the fixed platforms and charter boats. On occasions when anglers did not use the scheduled fixed platforms, additional visits were made to the marinas to obtain catch rates from charter boats. None of the fixed platforms were used by anglers on survey days in January or the charter boats in January, February, and December. In the period February through December, catch rates were obtained on 23 visits to Deer Point Dam, Bailey Bridge, and Hathaway Bridge, and on 24 visits to West Jetty and charter boats.

The catch rates obtained in this survey were from daytime angling only. Of the anglers interviewed on fixed platforms few had started fishing prior to 0600 h. Peak fishing hours were from 0900 to 1100. Similarly, relatively few of the surveyed charter boats fished prior to 0600; most fished during the hours 0600 to 1000. All fishing times were recorded to the nearest one-quarter hour. The survey ended at 1600 each day.

The fixed platforms were surveyed continuously throughout the day. The beginning time, catch, and kind of bait were recorded for each angler. Elapsed fishing time, additional catch, and bait changes were noted in repeated interviews of individual anglers. Fishes that were reportedly caught and returned to the water were classed as throwbacks; the number reported was accepted as accurate. Observed fishes were usually identified to species, but in some cases were identified only to family.

Charter boat captains attempted to schedule their first pelagic fishing trip each day to begin at 0600. Since most charters were for 4 h, peak fishing hours were from 0600 to 1000, although previously scheduled and nonscheduled trips departed and returned to the marinas throughout the day. Catch and effort data were obtained from as many of the returning charter boats as time and circumstance permitted.

FISHES CAUGHT

Anglers caught at least 55 species of fishes in 31 families (Table 1): 31 species at West Jetty, 21 at Hathaway Bridge, 20 at Deer Point Dam, 13 at Bailey Bridge, and 23 on charter boats. Sciaenidae contributed the greatest number of species (seven) followed by Carangidae (six); other families were represented by three or four species. Eight species of fishes constituted 72.9% of the total catch on fixed platforms: finfish (18.2%), sea catfish (12.8%), spotted seatrout (10.0%), blue runner (8.8%), crevalle jack (8.8%), sand seatrout (5.9%), Atlantic croaker (4.8%), and lefteye flounder (3.6%). King mackerel constituted 73.9% of the total catch by charter boats.

Table 1.—Common and scientific names of fishes caught by anglers at four locations in St. Andrew Bay system, Fla., and in adjacent coastal waters, 1973

Common name	Scientific name	Deer Pt. Dam	Bailey Bridge	Hathaway Bridge	West Jetty	Bay and coastal waters
Requiem sharks	CARCHARHINIDAE					
	Carcharhinus sp.			x	x	x
Hammerhead sharks	SPHYRNIDAE					
	Sphyrna sp.		x			
Stingrays	DASYATIDAE					
	Dasyatis sp.			x	x	
Morays	MURAENIDAE					
	Gymnothorax sp.	x		x		
Lizardfishes	SYNODONTIDAE					
Inshore lizardfish	*Synodus foetens*				x	x
Sea catfishes	ARIIDAE					
Sea catfish	*Arius felis*	x	x	x	x	x
Gafftopsail catfish	*Bagre marinus*	x	x	x		
Toadfishes	BATRACHOIDIDAE					
Gulf toadfish	*Opsanus beta*	x	x			
Needlefishes	BELONIDAE	x			x	
Sea basses	SERRANIDAE					
Sea bass	*Centropristis* sp.			x	x	
Sand perch	*Diplectrum formosum*			x		x
Gag	*Mycteroperca microlepis*				x	x

Table 1.—Continued.

Common name	Scientific name	Deer Pt. Dam	Bailey Bridge	Hathaway Bridge	West Jetty	Bay and coastal waters
Sunfishes	CENTRARCHIDAE					
Bluegill	*Lepomis macrochirus*	x				
Redear sunfish	*Lepomis microlophus*	x				
Bluefishes	POMATOMIDAE					
Bluefish	*Pomatomus saltatrix*				x	x
Cobias	RACHYCENTRIDAE					
Cobia	*Rachycentron canadum*					x
Jacks and pompanos	CARANGIDAE					
Blue runner	*Caranx crysos*	x	x	x	x	x
Crevalle jack	*Caranx hippos*	x	x	x	x	x
Horse-eye jack	*Caranx latus*			x		
Leatherjacket	*Oligoplites saurus*	x			x	x
Greater amberjack	*Seriola dumerili*					x
Florida pompano	*Trachinotus carolinus*				x	
Dolphins	CORYPHAENIDAE					
Pompano dolphin	*Coryphaena equisetis*					x
Dolphin	*Coryphaena hippurus*					x
Snappers	LUTJANIDAE					
Red snapper	*Lutjanus campechanus*					x
Gray snapper	*Lutjanus griseus*	x		x	x	
Vermilion snapper	*Rhomboplites aurorubens*				x	
Grunts	POMADASYIDAE					
Tomtate	*Haemulon aurolineatum*				x	
Pigfish	*Orthopristis chrysoptera*	x	x	x	x	
Porgies	SPARIDAE					
Sheepshead	*Archosargus probatocephalus*	x	x		x	
Pinfish	*Lagodon rhomboides*	x	x	x	x	x
Drums	SCIAENIDAE					
Silver perch	*Bairdiella chrysura*	x	x	x		
Spotted seatrout	*Cynoscion nebulosus*	x	x	x	x	x
Sand seatrout	*Cynoscion arenarius*	x	x	x		
Spot	*Leiostomus xanthurus*	x			x	
Atlantic croaker	*Micropogon undulatus*	x	x	x	x	
Black drum	*Pogonias cromis*	x	x		x	
Red drum	*Sciaenops ocellata*	x				x
Spadefishes	EPHIPPIDAE					
Atlantic spadefish	*Chaetodipterus faber*			x	x	
Parrotfishes	SCARIDAE				x	
Mullets	MUGILIDAE					
	Mugil sp.				x	
Barracudas	SPHYRAENIDAE					
Great barracuda	*Sphyraena barracuda*					x
Cutlass fishes	TRICHIURIDAE					
Atlantic cutlassfish	*Trichiurus lepturus*					x
Mackerels and tunas	SCOMBRIDAE					
Wahoo	*Acanthocybium solanderi*					x
Little tunny	*Euthynnus alletteratus*			x	x	x
King mackerel	*Scomberomorus cavalla*					x
Spanish mackerel	*Scomberomorus maculatus*			x	x	x
Billfishes	ISTIOPHORIDAE					
Sailfish	*Istiophorus platypterus*					x
Searobins	TRIGLIDAE					
	Prionotus sp.				x	
Lefteye flounders	BOTHIDAE					
	Paralichthys sp.			x	x	
Triggerfishes and Filefishes	BALISTIDAE					
Gray triggerfish	*Balistes capriscus*			x	x	x
Planehead filefish	*Monacanthus hispidus*			x		
Boxfishes	OSTRACIIDAE					
Scrawled cowfish	*Lactophrys quadricornis*			x		
Puffers	TETRAODONTIDAE					
Southern puffer	*Sphoeroides nephelus*			x		
Porcupinefishes	DIODONTIDAE					
Striped burrfish	*Chilomycterus schoepfi*			x	x	

VARIATION IN CATCH RATES BY BAIT TYPE

Intangible differences in angling experience are recognized as a source of variation in catch rates among anglers participating in a mixed-creel sport fishery (Caillouet and Higman 1973). The anglers interviewed on the fixed platforms in the St. Andrew Bay system were particularly diverse in their selection of fishing tackle and bait and in their method of fishing. Many of the anglers were visitors who had little saltwater fishing experience or knowledge of the available species of fishes. Most still-fished with dead shrimp or squid on the bottom. The experienced anglers, in contrast, selected baits that they regarded as most effective in catching a particular species of fish. Inexperienced anglers' catches consisted mostly of demersal fishes, while experienced anglers' catches consisted of both demersal and pelagic fishes.

The relative importance of bait type to angler success (catch rate) and bait preference of 10 species of fishes were investigated. According to the catch rate data, squid was the most effective of the eight bait types used by anglers on fixed platforms. The effectiveness of that particular bait may be attributed in part to its leather-like toughness and its appeal to pinfish, a species that was usually available at all the platforms. Because of its toughness, it is less easily removed from the hook by "nibblers" thus increasing fishing time by reducing the time spent rebaiting, although my personal observations and experience indicate that fresh dead shrimp will attract more species of fish at a faster rate than will squid. The highest average catch rate in any month (November) was achieved by anglers using dead shrimp. That average was 4.47 fish/h (Table 2), but the catches consisted mostly of pinfish, sea catfish, and unidentified throwbacks.

The experienced angler seeking spotted seatrout, a highly prized food and game fish, generally fished with either live shrimp or artificial lures. The catch rates indicate live shrimp was 3.6 times more effective than lures (Table 3). The comperatively fast moving pelagic fishes such as blue runner and crevalle jack apparently preferred fast moving baits, as the highest catch rates were obtained by anglers using artificial lures.

The fishes that were caught and the percentage composition of the catch from each platform are presented in

Table 2.—Variation in catch rates of saltwater fishes caught by interviewed anglers on fixed platforms in the St. Andrew Bay system, Fla., 1973, by bait type and month. (hrs = hours of angling, c/h = average catch per hour.)

	Bait type															
			Fish						Shrimp				Artificial lure		Fiddler crab	
	Squid		Live		Dead		Cut		Live		Dead					
Month	hrs	c/h	hrs	c/h	hrs	c/h	hrs	c/h	hrs	c/h	hrs	c/h	hrs	c/h	hrs	c/h
Feb.	2.25	0.00	—	—	—	—	—	—	23.50	0.51	15.00	0.00	16.00	0.12	10.00	0.10
Mar.	13.00	0.85	0.25	0.00	—	—	4.00	0.75	4.25	0.94	31.25	1.06	19.25	0.00	15.25	0.72
Apr.	19.00	1.42	3.50	0.86	—	—	—	—	—	—	68.75	1.64	23.25	0.26	12.75	0.24
May	12.00	3.83	6.50	4.31	—	—	17.00	0.94	—	—	66.25	1.36	31.50	0.98	—	—
June	30.75	1.72	19.50	0.51	7.50	0.00	9.50	0.10	—	—	83.00	0.96	5.50	3.09	4.00	3.25
July	52.50	1.41	—	—	2.25	0.44	47.75	0.67	1.50	0.00	120.75	0.69	7.50	0.27	3.00	0.00
Aug.	82.25	1.08	—	—	—	—	18.25	0.27	2.00	0.00	151.00	0.84	19.75	0.05	—	—
Sept.	7.00	1.14	0.25	0.00	1.00	0.00	1.50	0.00	11.75	0.59	72.00	0.40	21.00	0.38	—	—
Oct.	34.75	1.12	7.25	1.10	—	—	6.00	0.50	7.00	3.28	115.25	1.29	6.00	2.50	3.50	0.00
Nov.	15.00	1.07	3.75	0.53	5.00	2.00	21.25	1.22	25.50	1.10	21.50	4.47	42.00	2.74	10.00	0.33
Dec.	—	—	0.75	0.00	—	—	1.00	1.00	16.50	1.82	10.25	0.88	27.25	1.47	—	—
Total	268.50		41.75		15.75		126.25		92.00		755.00		219.00		58.50	
Average		1.35		1.22		1.08		0.69		1.13		1.07		1.08		0.53

Table 3.—Average catch per hour of 10 saltwater fishes caught by interviewed anglers on fixed platforms in the St. Andrew Bay system, Fla., 1973, by bait type. (Hours of angling.)

	Bait type						
		Fish			Shrimp		
Species	Squid (268.50)	Live (41.75)	Dead (15.75)	Cut (126.25)	Live (92.00)	Dead (755.50)	Lures (219.00)
Pinfish	0.38	0.00	0.00	0.03	0.03	0.16	0.00
Sea catfish	0.24	0.00	0.00	0.03	0.00	0.13	0.00
Spotted seatrout	0.00	0.02	0.00	0.00	0.71	0.04	0.20
Blue runner	0.10	0.00	0.06	0.10	0.00	0.09	0.12
Crevalle jack	0.04	0.00	0.00	0.00	0.00	0.01	0.41
Sand seatrout	0.00	0.00	0.00	0.09	0.00	0.06	0.00
Atlantic croaker	0.04	0.02	0.00	0.02	0.00	0.06	0.01
Flounder	0.01	0.14	0.00	0.02	0.00	0.00	0.11
Tomtate	0.03	0.00	0.00	0.00	0.16	0.00	0.00
Spadefish	0.02	0.00	0.00	0.00	0.00	0.04	0.00

Tables 4-8. The monthly average catches per hour from fixed platforms are shown in Table 9.

CATCH AND CATCH RATES

Deer Point Dam

At Deer Point Dam 236 interviewed anglers caught 20 species of fishes and unidentified throwbacks (Table 4) in 401.0 h of angling (Table 9). In the February-December period, the catch rate averaged 1.0 fish/h of angling and ranged from 0.0 to 10.7 fish/h by individual anglers (Fig. 2).

The platform was frequently used by skilled anglers seeking spotted seatrout, particularly during the fall and early winter months. As a result of that effort, the spotted seatrout was the most commonely caught fish, amounting to 21.0% of the total catch. Pinfish and throwbacks comprised 39.3% of the total catch.

Bailey Bridge

The catch at Bailey Bridge consisted of 13 species of fishes (Table 5). They were caught by 99 interviewed anglers in 147.5 h of angling for an average catch rate of 1.2 fish/h in the 11-mo period of February through December (Table 9). Individual catches ranged from 0.0 to 6.5 fish/h (Fig. 2).

Bailey Bridge, like Deer Point Dam, was a favored platform for spotted seatrout anglers, particularly in late summer through early winter. Of the fishes that were caught, 37.1% consisted of this species. Pinfish, sea catfish, and throwbacks comprised 36.6% of the catch.

Hathaway Bridge

The old Hathaway Bridge with its removed center span serves as two public fishing piers. Located alongside U.S. Route 98, it is easily found by visiting anglers. The majority of the interviewed anglers were thought to be visitors to this area.

The catch by both resident and nonresident anglers consisted of 27 species of fishes (Table 6). The number of interviewed anglers was the highest and the average catch rate the lowest of the surveyed platforms. On that platform, 436 interviewed anglers fished 757.0 h and averaged 0.9 fish/h during a 10-mo period, March through December (Table 9). Individual catch rates ranged from 0.0 to 10.2 fish/h.

Pinfish, sea catfish (usually discarded), and throwbacks accounted for 55.0% of the catch. The sand seatrout, one of the more popular fishes at the Hathaway Bridge, was available throughout most of the year and accounted for 12.6% of the total catch.

West Jetty

The West Jetty, accessible through St. Andrew State Park and by boat, is used extensively by both resident and nonresident anglers. Located at the inlet to St. Andrew Bay, the jetty provides the angler with a platform to fish for estuarine and oceanic fishes simultaneously. The rocky jetty and strong current through the inlet is the nemesis of the inexperienced angler, particularly those that attempt to fish for bottom fish. For that kind of fishing, a heavy weight, which is frequently fouled in the rocks on retrieval, is required. Many of the anglers who

Table 4.—Monthly catch of fishes by 236 interviewed anglers at Deer Point Dam, 1973. (No anglers were present at Deer Point Dam on survey days during January.)

	Month (number of anglers)												
Species	F(10)	M(15)	A(28)	M(13)	J(32)	J(28)	A(21)	S(13)	O(20)	N(28)	D(28)	Sum	Percent
Spotted seatrout		6	3		16	2		7	1	24	29	88	21.0
Pinfish			7	8	14				31	19	8	87	20.7
Throwback*			1	8	3	25	22	2	6	5	6	78	18.6
Sea catfish			2	1	3	26	9		13			54	12.8
Bluegill			27									27	6.4
Silver perch			11	3	6						1	21	5.0
Spot			11	2	5							18	4.3
Blue runner				1	9							10	2.4
Atlantic croaker			2	2	2	2				1		9	2.2
Crevalle jack									2		5	7	1.7
Pigfish				1					2	1		4	1.0
Black drum					2	1						3	0.7
Gray snapper									1	1	1	3	0.7
Red drum	1									1		2	0.5
Leatherjacket				1	1							2	0.5
Sheepshead		1										1	0.2
Redear sunfish			1									1	0.2
Gafftopsail catfish									1			1	0.2
Sand seatrout											1	1	0.2
Needlefish*									1			1	0.2
Moray*									1			1	0.2
Total	1	7	65	27	61	56	31	9	59	52	51	419	99.9

*Species unknown.

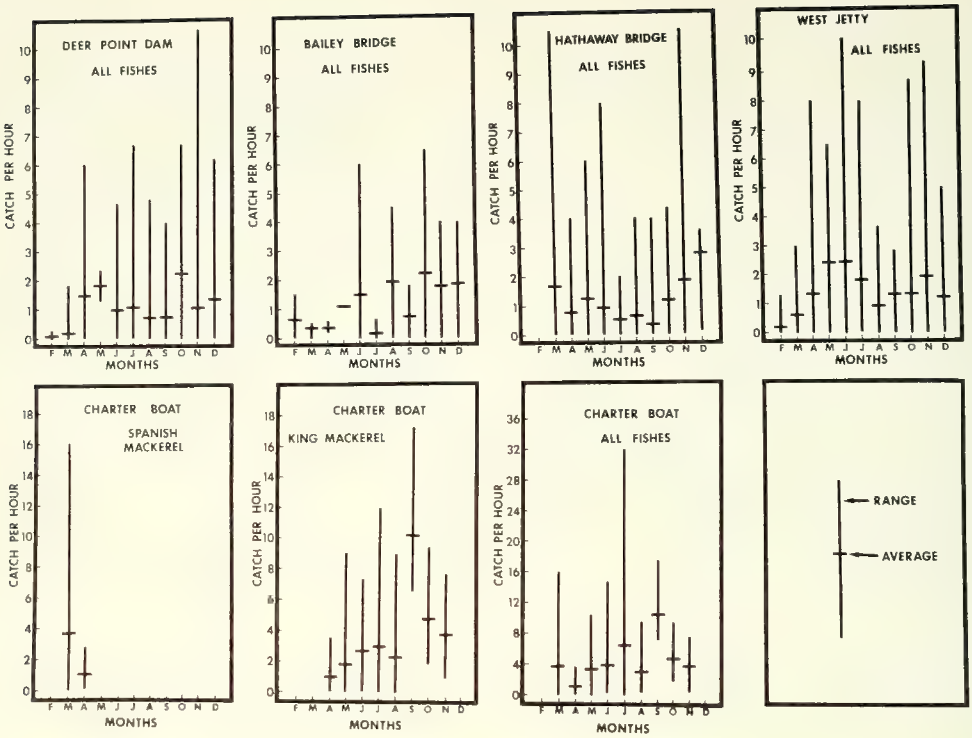

Figure 2.—Monthly range and average catch per hour of fishes by anglers on fixed platforms and charter boats in St. Andrew Bay system, Fla., and adjacent coastal waters, 1973.

were questioned about their fishing activity were not included in this survey, because most of their effort was spent replacing terminal tackle lost in the rocks.

The largest number (31) of species of food and game fishes that were caught from all platforms was available at the jetty (Table 7). The highest average catch rate from all platforms was also at the jetty. In the period February-December, an average catch rate of 1.3 fish/h was achieved by 419 fishermen in 748.0 h of angling (Table 9). The average catch rate for individuals ranged from 0.0 to 10.0 fish/h (Fig. 2).

Charter Boats

Charter boat anglers used similar tackle, baits, and fishing methods. Most trolled four lines, two weighted and two unweighted, irrespective of the number of anglers onboard. A 00-squid spoon or a similar spoon was commonly used for Spanish mackerel, and tandem rigs consisting of three 5/0-hooks baited with a whole round scad were standard for king mackerel. Because of the high degree of standardization, the catch and effort could be averaged (Ricker 1958) to derive meaningful indices of

Table 5.—Monthly catch of fishes by 99 interviewed anglers at Bailey Bridge, 1973. (No anglers were present at Bailey Bridge on survey days during January.)

	Month (number of anglers)												
Species	F(7)	M(11)	A(4)	M(2)	J(8)	J(14)	A(14)	S(5)	O(6)	N(19)	D(9)	Sum	Percent
Spotted seatrout	6						7	5	7	10	30	65	37.1
Throwback*					1		29		6	3		39	22.3
Pinfish			3	1						11		15	8.6
Sea catfish				1	1	2	5			1		10	5.7
Sheepshead		5	2							3		10	5.7
Black drum					9							9	5.1
Atlantic croaker									8	1		9	5.1
Silver perch				3	3				1			7	4.0
Sand seatrout										6		6	3.4
Pigfish					1							1	0.6
Gafftopsail catfish					1							1	0.6
Crevalle jack											1	1	0.6
Hammerhead*					1							1	0.6
Gulf toadfish									1			1	0.6
Total	6	5	5	5	17	2	41	5	23	35	31	175	110.0

*Species unknown.

Table 6.—Monthly catch of fishes by 436 interviewed anglers at Hathaway Bridge, 1973. (No anglers were present on Hathaway Bridge on survey days during January and February.)

	Month (number of anglers)											
Species	M(15)	A(30)	M(36)	J(29)	J(115)	A(85)	S(37)	O(53)	N(34)	D(2)	Sum	Percent
Throwback*	24		27		50	40	2	7	8	1	157	22.8
Sea catfish	3		5	5	15	62	16	14		2	122	17.5
Pinfish	2	17		3	3	17		30	30		102	14.6
Sand seatrout	8		4	1	3		3	46	23		88	12.6
Blue runner			42	19	3		1	10	5		80	11.5
Atlantic spadefish				8		27					35	5.0
Sand perch								6	10		16	2.3
Pigfish								2	13		15	2.2
Spanish mackerel							1		11		12	1.7
Atlantic croaker	1		1		2		4	1			9	1.3
Spotted seatrout			9								9	1.3
Moray*		1			1			4	2		8	1.1
Crevalle jack									7		7	1.0
Silver perch				2					3		5	0.7
Gray triggerfish						1		4			5	0.7
Southern puffer								4	1		5	0.7
Gafftopsail catfish								2	1		3	0.4
Little tunny						1			2		3	0.4
Striped burrfish			1	1							2	0.3
Seabass*				2							2	0.3
Stingray*								2			2	0.3
Gray snapper								1			1	0.1
Planehead filefish								1			1	0.1
Horseye jack				1							1	0.1
Shark*						1					1	0.1
Gulf toadfish								1			1	0.1
Scrawled cowfish								1			1	0.1
Flounder*								1			1	0.1
Total	38	18	89	42	77	149	27	137	116	3	696	99.4

*Species unknown.

the availability of Spanish and king mackerel to charter boat anglers.

Anglers on 125 charter boats caught 19 species of fishes (Table 8). The major fishing was devoted to king mackerel, and that fish comprised the greatest proportion of the catch (73.9%). Six species of fishes comprised 93.4% of the total catch. In addition to king mackerel, they were: dolphin (5.9%), Spanish mackerel (5.0%), little tunny (3.6%), blue runner (3.0%), and bluefish (2.0%). The greatest number of species of fishes was caught in May (12), June (11), and July (11). Only the Spanish mackerel was caught in March and the king mackerel in November.

The Spanish mackerel is usually among the first pelagic fishes to appear in local waters in the spring. In 1973, the first catch was on 16 March. During the period 16-30 March, the catch rates showed considerable variability among the boats. Catch rates of 0.0 to 16.0 fish/h were made by individual boats. The average for all boats was 3.7 fish/h (Fig. 2). Through the period 4-17 April the catches were less variable with ranges of 0.5 to 2.9 fish/h. The average for all boats was 1.1 fish/h, which suggests a 70% decline in available fish from the 16-30 March period.

The first catch of king mackerel in coastal waters off St. Andrew Bay was on 24 April and the last on 15 November. The dates more accurately reflect the beginning and the end of the fishing season rather than the arrival and departure of the fish. An occasional report was received of a catch of king mackerel prior to 24 April and after 15 November. Unfavorable weather and sea conditions often limit charter boat fishing trips into coastal waters in early spring and winter. The reluctance of charter boatmen to pursue a particular fish for their clients unless reasonably assured of the availability of fish is also an important factor. In season, 21% of the surveyed charter boats failed to catch a king mackerel in May, 4% failed in June, 14% failed in July, and 13% failed in August; none failed to catch one or more in late April, September, October, and early November.

According to the catch rate data, king mackerel increased in availability from an average of 1.0 fish caught per hour trolling in late April to 10.2 fish/h through September (Fig. 2). In September, the average catch rate for individual boats ranged from 7.1 to 17.5 fish/h. From the September high the catch rate declined rapidly to an average of 4.8 in October and to 3.8 in early November. The charter boat fishing season ended by mid-November because of cold weather, rough sea, and lack of clients.

DISCUSSION

On-site interviews are acknowledged as being the most reliable method of obtaining angler's catch and catch rates. Bias due to recall, vanity, and other reasons are

Table 7.—Monthly catch of fishes by 419 interviewed anglers at West Jetty, 1973. (No anglers were present at West Jetty on survey days during January.)

Species	F(24)	M(22)	A(44)	M(25)	J(36)	J(53)	A(44)	S(29)	O(85)	N(44)	D(13)	Sum	Percent
	Month (number of anglers)												
Throwback*			67	76	29	99	22	14	47	10		364	36.8
Crevalle jack					1			1	33	91	3	129	13.1
Pinfish			4	1	7	14	28	4	32	5		95	9.6
Flounder*			1	1				3	25	20	8	58	5.9
Blue runner				13	21	13	6		1			54	5.5
Atlantic croaker									48	4		52	5.3
Tomtate		8							19	7	5	39	4.0
Sea catfish			15			1	6	1		1		24	2.4
Inshore lizardfish										4	18	22	2.2
Little tunny			1		16	1						18	1.8
Spanish mackerel	1		2		1			3		10		17	1.7
Mullet*									16			16	1.6
Gray snapper						1			2	8	2	13	1.3
Pigfish			1	3		2			4	2	1	13	1.3
Sheepshead	6	6	1									13	1.3
Spot							10					10	1.0
Gag grouper		1	6				2					9	0.9
Florida pompano			4	3								7	0.7
Bluefish	1			2				2			1	6	0.6
Sea robin*											4	4	0.4
Stingray*			2						2			4	0.4
Gray triggerfish			1						2			3	0.3
Vermilion snapper			1			2						3	0.3
Leatherjacket				3								3	0.3
Black drum		1		1								2	0.2
Spotted seatrout			1	1								2	0.2
Parrotfish*					1					1		2	0.2
Needlefish*									1		1	2	0.2
Shark*			1									1	0.1
Atlantic spadefish				1								1	0.1
Striped burrfish				1								1	0.1
Seabass*					1							1	0.1
Total	8	16	108	106	77	133	74	28	232	163	43	988	99.9

*Species unknown.

Table 8.—Monthly catch of fishes by anglers on 125 charter boats, 1973. (No charter boats fished on survey days during January, February, and December.)

Species	M(6)	A(13)	M(14)	J(24)	J(14)	A(31)	S(7)	O(12)	N(4)	Sum	Percent
	Month (number of charter boats)										
King mackerel		25	79	235	172	299	258	266	9	1,343	73.9
Dolphin			56	36	3	12	1			108	5.9
Spanish mackerel	61	26	4		1					92	5.0
Little tunny			5	13	6	36	4	1		65	3.6
Blue runner			8	43	1	3				55	3.0
Bluefish					38					38	2.0
Amberjack*			27			7				34	1.8
Gray triggerfish				12		14	1	4		31	1.7
Ladyfish						9				9	0.5
Cobia		1	1	4			2			8	0.4
Great barracuda			3	1		3				7	0.4
Gag grouper			4	3						7	0.4
Crevalle jack		3	1	1			1			6	0.3
Shark*			3		2					5	0.3
Red drum					3					3	0.2
Wahoo			1							1	<0.1
Sailfish				1						1	<0.1
Sand perch				1						1	<0.1
Sea catfish					1					1	<0.1
Inshore lizardfish					1					1	<0.1
Atlantic cutlassfish					1					1	<0.1
Total	61	55	192	350	229	383	267	271	9	1,817	100.0

*Species unknown.

Table 9.—Monthly average catch per hour (c/h) of fishes by interviewed anglers on fixed platforms in St. Andrew Bay system, Fla., 1973. (No anglers were observed on fixed platforms in January or on Hathaway Bridge in February.)

	Deer Point Dam			Bailey Bridge			Hathaway Bridge			West Jetty		
Month	No. of anglers	Hours fishes	Average c/h	No. of anglers	Hours fished	Average c/h	No. of anglers	Hours fished	Average c/h	No. of anglers	Hours fished	Average c/h
Feb.	10	13.25	0.08	7	8.50	0.71	—	—	—	24	48.50	0.16
Mar.	15	27.25	0.26	11	15.25	0.33	15	22.00	1.73	22	28.75	0.56
Apr.	28	57.75	1.12	4	15.50	0.32	30	26.75	0.67	44	83.50	1.29
May	13	16.50	1.64	2	4.50	1.11	36	73.75	1.21	25	45.00	2.36
June	32	58.50	1.04	8	12.25	1.39	29	48.00	0.88	36	65.25	1.18
July	28	50.75	1.10	14	14.25	0.14	115	133.00	0.58	53	74.75	1.78
Aug.	21	44.00	0.70	14	21.75	1.89	85	203.00	0.73	44	79.75	0.93
Sept.	13	12.75	0.71	5	7.25	0.69	37	71.00	0.38	29	21.75	1.29
Oct.	20	34.50	1.71	6	10.50	2.19	53	112.25	1.22	85	181.25	1.28
Nov.	28	46.50	1.12	19	20.50	1.71	34	64.50	1.80	44	84.25	1.93
Dec.	28	39.25	1.30	9	17.25	1.80	2	1.75	1.71	13	35.25	1.22
Total	236	401.00		99	147.50		436	756.00		419	748.00	
Average			1.04			1.19			0.92			1.32

minimized. Such data may or may not provide an accurate measure of the availability of fishes, however. Several factors affect angling success. Among those are the species that are sought, fishing location, bait (method), and angling effort.

In 2,053.5 h of angling from fixed platforms in the St. Andrew Bay system, at least 55 species of fishes were caught by the interviewed anglers. Other food or game fish known to occur in the system were not caught. The tarpon (*Megalops atlantica*), red snapper (*Lutjanus campechanus*), and snook (*Centropomus* sp.) are examples. Those fishes are not believed to be abundant, but an occasional catch would be expected. Perhaps, more importantly, none of the interviewed anglers were aware of their presence or directed their efforts specifically for them.

The caught fishes were not distributed equally throughout the study area, judging from the percentage composition and number of species landed from each platform. The spotted seatrout appeared to be available in greater number at Deer Point Dam than at the other locations. The percentage of the total catch was 21.0% at Deer Point Dam, 0.2% at West Jetty, and 0.0% in coastal waters. In contrast, the crevalle jack comprised 0.3% of the catch in coastal waters, 13.1% at West Jetty, and 1.6% at Deer Point Dam. All dolphin, amberjack, great barracuda, wahoo, and Atlantic cutlassfish were caught in coastal waters, and all tomtate and gray and vermilion snappers were caught at the West Jetty.

The catch rates also differed by bait type. The highest average catch rate achieved by all anglers on fixed platforms for all months was with dead squid (1.4 fish/h), closely followed by live bait fish (1.2 fish/h), live shrimp (1.1 fish/h), and dead shrimp (1.1 fish/h). The average catch rate with cut fish and fiddler crabs was 51% and 39%, respectively, of that achieved with dead squid.

According to the data on bait preference, significantly higher catch rates could have been obtained by using the bait preferred by available fishes. The highest average catch rate for spotted seatrout, for example, was 0.7 fish/h with live shrimp. That rate was 3.6 times greater than with lures and 17.8 times greater than with dead shrimp. The highest average catch rate for crevalle jacks was with lures. That rate, 0.4 fish/h, was 10.2 times greater than with squid, the next most effective bait.

It seems apparent that the catch and catch rates obtained by this creel census are of limited value for indexing the availability of fishes to anglers on fixed platforms. The data do provide a general measure of species availability and angling success by a diverse group of anglers that probably constitute the majority of all anglers. The catch rates of Spanish and king mackerels by charter boat anglers, however, are viewed as reliable measures of their availability and relative abundance. The reliability resulted from the selection of a sample of anglers having considerable experience angling for those fishes. The captains and mates on those boats are, of course, professional anglers; their fishing methods are similar and their effort competitive.

ACKNOWLEDGMENTS

I thank F. A. Kalber, G. R. Huntsman, and J. B. Higman for reviewing this manuscript.

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Steven K. Cook and Keith A. Hausknecht

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Expendable Bathythermograph Observations From the NMFS/MARAD Ship of Opportunity Program for 1974

STEVEN K. COOK and KEITH A. HAUSKNECHT[1]

ABSTRACT

Results of the fourth year of operation of the NMFS/MARAD Ship of Opportunity Program (SOOP) are presented in the form of vertical distributions of temperature and horizontal distributions of sea surface temperature and salinity. Operational and data management procedures also are discussed. Included are descriptive analyses of the most dynamic transects showing the Yucatan, Loop, Florida, and Gulf Stream currents and related eddies. Also, characteristics of the cold cell of bottom water on the Atlantic continental shelf are discussed.

INTRODUCTION

In midyear of 1970 a cooperative expendable bathythermograph (XBT) program was initiated between the National Marine Fisheries Service (NMFS) and the Maritime Administration (MARAD) of the U.S. Department of Commerce (Cook 1973, 1975, 1976). The program, conducted in support of the Marine Resources Monitoring Assessment and Prediction Program (MARMAP) of the NMFS, involved the use of maritime cadets from the Kings Point Maritime Academy to collect XBT data on board merchant ships operating along the east and Gulf coasts of the United States. The objective of this cooperative program was to identify and describe seasonal and year-to-year variations of temperature and circulation in the major current regimes of the western tropical Atlantic, Caribbean Sea, Gulf of Mexico, and western North Atlantic, utilizing merchant ships as relatively inexpensive platforms for the collection of data.

AREAS OF STUDY

Ship routes were selected to obtain regular sampling in the most dynamic areas of the Gulf of Mexico and western North Atlantic. The features of principal interest were the Yucatan Current, Loop Current, Florida Current, Gulf Stream, Shelf Water-Slope Water front, and a cold-water cell in the Middle Atlantic Bight.

DATA ACQUISITION AND PROCESSING

The Ship of Opportunity effort for 1974 consisted of a total of 34 cruises—18 sailing from New Orleans, 12 from New York, and 4 from Norfolk. Fifty-three transects of subsurface temperature observations and associated surface data were obtained. A total of 739 XBT's were launched; of these 514 (70%) were considered of sufficient quality to be incorporated into the transects presented.

Subsurface temperature data were obtained by use of Sippican XBT systems. At the same time, surface water samples were collected with bucket thermometers for salinity determination ashore using a Beckman inductive salinometer calibrated with standard (Copenhagen) water at least once every 30 samples.

The XBT traces were submitted to the National Oceanographic Data Center (NODC) where they were digitized, key punched, and quality controlled. Finally, these processed data were listed in printout form and machine plotted. The plots produced by NODC were essentially camera-ready and needed little hand correcting. The few corrections necessary were made by discarding anomalous XBT observations that could not be supported by other associated data such as sea surface temperature or other nearby XBT observations. Consequently a vertical section plot may have one or two missing observations, resulting from the deletion of inaccurate subsurface data.

The fourth year of operation of the NMFS/MARAD Ship of Opportunity Program (SOOP) was enhanced by the inclusion of Coast Guard cutters as ships of opportunity. The Coast Guard cutters that occupy Ocean Weather Station HOTEL (OWSH) (lat. 37°N, long. 71°W) began taking hourly XBT observations between Norfolk, Va., and OWSH in August. This transect was occupied monthly while OWSH was being maintained, usually from August through April. We plan to resume this section when OWSH is again occupied.

Approximately 225 XBT drops and associated surface data are not included because the observations were much too widely separated in time and space to be useful in the analysis. All data collected were archived by the NODC and are available to interested persons through the NODC, Washington, D.C. 20235.

---

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Further details concerning the acquisition or processing of data from the cruises considered here can be obtained from the authors.

For purposes of this report all descriptive figures have been included within the text and all vertical temperature sections have been organized geographically and chronologically and included as Appendix Figures.

TRANSECT ANALYSIS

Gulf of Mexico (Fig. 1, Appendix Figs. 1-16)

Loop Current.—In 1974 the Loop Current was crossed on seven occasions (Table 1) by SOOP ships. There were two crossings in March (Appendix Figs. 1, 2), one in April (Appendix Fig. 3), two in May (Appendix Figs. 4, 5), and one each in June (Appendix Fig. 6) and July (Appendix Fig. 8).

Utilizing 20°C at 125 m as the left edge of the Loop Current (G. A. Maul, pers. commun.), the position of the front can be monitored from XBT data. Most migrations of the Loop Current edge ranged between lat. 22°N and 24°N. Movements of more than 1° of latitude in less than 2 wk were not uncommon. One migration of about 90 nautical miles (167 km) occurred within 9 days, between 28 June (Appendix Fig. 6) and 7 July (Appendix Fig. 8).

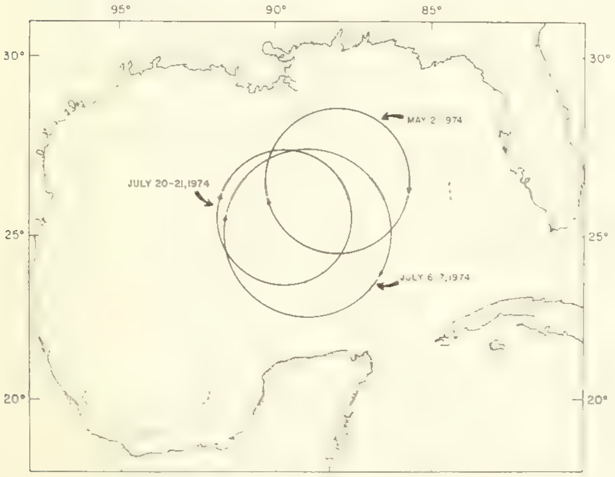

Figure 1.—Composite plot of Gulf of Mexico eddy positions.

Table 1.—Crossings of the Loop Current made by SOOP vessels in 1974.

Appendix figure	Ship	Station no.	Date
1	*Delta Sud*	20-23	8-9 Mar.
2	*Delta Norte*	11-15	21-23 Mar.
3	*Delta Sud*	28-31	15-17 Apr.
4	*Delta Sud*	40-32	21 May
5	*Delta Sud*	22-24	27-29 May
6	*Delta Sud*	9-2	28-29 June
8	*Delta Sud*	17-20	7-8 July

The Loop Current was crossed by the *Delta Sud* on 9 March at lat. 23°15'N at station 23 (Appendix Fig. 1). Again on 23 March at lat. 22°30'N the *Delta Norte* crossed the Loop Current between stations 12 and 13 (Appendix Fig. 2).

In April (Appendix Fig. 3) a crossing of the Loop Current by the *Delta Sud* determined the front to be at lat. 22°N.

In May (Appendix Fig. 4) the Loop Current appeared as a broad flowing current between stations 40 and 32. At this time the front's position had intruded up to lat. 24°N. Again in May (Appendix Fig. 5), the *Delta Sud* crossed the Loop Current between stations 22 and 24. At that time the front had receded back to lat. 23°N.

In June (Appendix Fig. 6) the Loop Current again appeared as a broad flow between stations 9 and 2. The main front (20°C and 125 m) showed up between stations 7 and 8 at about lat. 24°N. Also present at this time was a counterflow around Cuba that showed up between stations 1 and 2.

In July (Appendix Fig. 8), the Loop Current was crossed at lat. 22°30'N between stations 17 and 18.

Eddies.—In 1974 the SOOP ships in the Gulf of Mexico crossed eddies most of which were anticyclonic with warm-cores on 19 occasions (Table 2). Eddies were crossed in March through August and November (Appendix Figs. 1-7, 9-14). The diameters of these eddies where crossed ranged from about 75 nautical miles (138 km) to 335 nautical miles (621 km) and ranged in depth from 200 to 700 m. Some eddies were crossed more than once. One anticyclonic eddy (Appendix Figs. 4, 7, 9) in particular was easy to track because it had a subsurface signature in the form of a peak in the 26° isotherm that was opposite to the rest of the isotherms. This peak also happened to occur at the center of the eddy. This eddy was crossed on 21 May (Appendix Fig. 4), 7 July (Appendix Fig. 7), and 21 July (Appendix Fig. 9) and migrated in position from lat. 26°24'N, long. 87°52'W (Appendix Fig. 4) to lat. 24°55'N, long. 88°55'W (Appendix Fig. 7) to lat. 25°26'N, long. 89°44'W (Appendix Fig. 9). On all crossings the eddy structure extended to depths of greater than 600 m. The eddy moved 140 nautical miles (259 km) in 2 mo in a southwesterly direction or about 2.3 nautical miles (4.3 km)/day (Fig. 1).

Low salinity surface water.—River runoff along the Gulf coast, which forms a plume detectable by low surface salinities (<34.5°/₀₀), sometimes extended great distances offshore (well beyond the shelf break). Nine transects of low salinity water were detected in 1974 (Table 3). Crossings in March, April, May, June, July, and August (Appendix Figs. 1, 3, 4, 6, 7, 9-12) showed large variations in salinity ranges and horizontal extent.

At times the extent of the low salinity surface waters in the eastern Gulf of Mexico seemed to be controlled by the northward migrations of either eddies or the Loop Cur-

Table 2.—Location and characteristics of eddies transected in the Gulf of Mexico by SOOP vessels in 1974.

Appendix figure	Ship	Station no.	Station coordinates (lat., long.)	Date	Depth (m)	Diameter nm (km)
1	*Delta Sud*	12	26°56′N, 91°33′W	8-9 Mar.	>500	170 (315)
		16	25°08′N, 89°21′W		>500	170 (315)
		17	24°56′N, 89°05′W		>500	120 (222)
		20	23°40′N, 87°32′W		>500	120 (222)
2	*Delta Norte*	1	27°52′N, 92°51′W	21-23 Mar.	>600	200 (370)
		5	25°09′N, 89°47′W		>600	200 (370)
		6	24°50′N, 89°28′W		>700	175 (324)
		11	22°55′N, 87°05′W		>700	175 (324)
3	*Delta Sud*	11	27°01′N, 91°51′W	15-17 Apr.	>600	95 (176)
		16	26°00′N, 90°29′W		>600	95 (176)
		16	26°00′N, 90°29′W		>600	290 (537)
		28	22°46′N, 86°30′W		>600	290 (537)
4	*Delta Sud*	40	24°29′N, 86°51′W	21 May	600	245 (453)
		49	28°09′N, 88°48′W		600	245 (453)
5	*Delta Sud*	4	27°28′N, 92°16′W	27-29 May	>600	120 (222)
		9	26°10′N, 90°48′W		>600	120 (222)
		9	26°10′N, 90°48′W		>600	300 (556)
		22	23°10′N, 86°55′W		>600	300 (556)
6	*Delta Sud*	9	25°41′N, 87°08′W	28-29 June	>500	175 (324)
		17	28°08′N, 88°52′W		>500	175 (324)
7	*Delta Sud*	4	27°17′N, 91°44′W	6-7 July	>600	335 (621)
		14	23°30′N, 87°18′W		>600	335 (621)
9	*Delta Norte*	8	27°48′N, 92°44′W	20-21 July	>600	140 (259)
		13	26°17′N, 90°54′W		>600	140 (259)
		13	26°17′N, 90°54′W		>700	195 (361)
		22	24°17′N, 88°17′W		>700	195 (361)
10	*Mayaguez*	1	29°01′N, 88°44′W	17-18 Aug.	>600	165 (306)
		7	27°22′N, 86°41′W		>600	165 (306)
11	*Mayaguez*	19	24°24′N, 82°39′W	25-26 Aug.	>700	240 (445)
		24	26°54′N, 85°53′W		>700	240 (445)
12	*Mayaguez*	1	28°44′N, 88°26′W	28-29 Aug.	>600	140 (259)
		6	27°19′N, 86°27′W		>600	140 (259)
		6	27°19′N, 86°27′W		>200	150 (278)
		9	25°37′N, 84°22′W		>200	150 (278)
13	*Delta Sud*	10	25°37′N, 87°33′W	2 Nov.	>600	[1]75 (139)
		13	26°42′N, 88°06′W		>600	[1]75 (139)
14	*Delta Sud*	21	27°36′N, 87°36′W	6 Nov.	>600	160 (296)
		26	26°07′N, 85°21′W		>600	160 (296)

[1] Only about one-half of this eddy was transected.

Table 3.—Low salinity ($< 34.5^{\circ}/_{\circ\circ}$) coastal water encountered by SOOP vessels in the northern Gulf of Mexico in 1974.

Appendix figure	Ship	Date	Station no.	Water depth at seaward edge (m)	Offshore extent nm (km)
1	*Delta Sud*	8-9 Mar.	2-4	32	50 (93)
3	*Delta Sud*	15-17 Apr.	1-4	38	70 (130)
4	*Delta Sud*	21 May	49-51	124	70 (130)
6	*Delta Sud*	28-29 June	16-18	>500	90 (167)
7	*Delta Sud*	6-7 July	1-3	144	195 (361)
9	*Delta Norte*	20-21 July	1-11	>800	230 (426)
10	*Mayaguez*	17-18 Aug.	1-3	>800	85 (157)
11	*Mayaguez*	25-26 Aug.	25-27	>800	210 (389)
12	*Mayaguez*	28-29 Aug.	1-6	>800	200 (371)

rent itself. The offshore extent of the low salinity surface water shown in Appendix Figures 4, 7, and 9 apparently was blocked by the presence of one particular anticyclonic eddy. The southwestward migration of this eddy (as discussed above) removed the block and allowed the plume to extend farther offshore. In some instances the low salinity surface waters were entrained into the eddy structure (Appendix Figs. 6, 9, 10, 12). In most cases when this occurred the low salinity water appeared on only the northern side of the eddy. Peaks in the surface salinity (Appendix Figs. 4, 9, 11, 12) indicate the instances where low salinity water was transected, exited, and then transected again, which we interpreted as low salinity surface waters being entrained by the leading edges of eddies. The interaction of coastal water with eddies probably is a significant mechanism for the mixing of the less saline coastal waters with the more saline oceanic waters in the Gulf of Mexico.

Western Atlantic Transects (Figs. 2-10 and Appendix Figs. 17-35)

Specific features that were monitored in the western North Atlantic by the program were the position of the Gulf Stream, variations in temperature and position of the bottom water cold cell on the continental shelf, position of the Shelf Water-Slope Water front, and eddies formed from the Gulf Stream. Where data were available and observations were close enough in time to permit comparison, correlations were made with the National Environmental Satellite Service (NESS) Experimental Gulf Stream Analysis (N-69) charts and *The Gulf Stream Monthly Summary* which show the positions of the Gulf Stream and associated features.

Characteristics of the bottom water cold cell.—In his discussion of temperature patterns in continental shelf water, Bigelow (1933) described a core of cold bottom water that extended from south of Long Island to the mouth of the Chesapeake and was evident throughout the summer months. According to Bigelow, this core was surrounded entirely by warmer water and could receive no replenishment during the summer; thus, he concluded it was formed in wintertime and then persisted throughout the year. Further descriptions of this cold cell have been given by Ketchum and Corwin (1964) and Whitcomb (1970). The data which are presented here show the formation, structure, and modification of this cell during 1974.

Nine observations of the cold cell were made by SOOP vessels in 1974 (summarized in Table 4). For purposes of discussion, the observations have been grouped into three separate geographic areas, chosen because they represent regularly scheduled merchant ship cruise tracks. These tracks have been designated as the MORMAC transect (Fig. 2), *Santa Cruz* transect (Fig. 3), and HOTEL transect (Fig. 4). The MORMAC transect is the cruise track used by Moore McCormack Line ships and closely follows a line between New York and Bermuda. The *Santa Cruz* transect extends from New York to Cape Hatteras, approximately along long. 74°W. The HOTEL transect is the cruise track used by Coast Guard cutters operating between Norfolk and OWSH. In the following discussion, the seasonal characteristics and variations in the cold cell temperature and position along each transect are summarized.

The temperature structure of water on the continental shelf during February (Appendix Fig. 17) should be considered, because the cold cell was formed from these waters and the minimum temperature that could be attained in the cell was dependent upon conditions during the winter months. At this time, cold water (7°-12°C) extended from surface to bottom on the shelf and the structure of the cell had not yet been established by stratification.

Along the MORMAC transect, the first evidence that the cell had formed was obtained on 6 May (Appendix Fig. 21). The characteristic shape of the cell was shown by the outline of the 11°C isotherm in shelf waters. Within this "cell-like" structure, temperatures ranged from less than 9° to 11°C and the cell extended from a minimum bottom depth of 20 m to a maximum of 38 m. The horizontal extent was 65 nautical miles (120 km) and the cell was approximately 20 m thick at the center. When next observed on 14 August (Appendix Fig. 25), temperatures in the cell ranged from less than 9° to 13°C and the bottom depth range of 40-55 m indicated that the cell was migrating into deeper water. The last observation was made on 3 October (Appendix Fig. 30). By this time, temperatures had warmed to 14°C in the outer edges of the cell and it had moved over the shelf break. The depth range extended from 34 to 99 m. These changes in temperature and depth are summarized in Figure 2.

Along the *Santa Cruz* transect the earliest observation of the cold cell was made on 6 May (Appendix Fig.

Table 4.—Characteristics of the bottom water cold cell detected by SOOP vessels in 1974.

Transect	Ship	Date	Appendix figure	Minimum bottom depth (m)	Maximum bottom depth (m)	Depth at center (m)	Approximate thickness at center (m)	Temperature range (°C)	Horizontal extent nm (km)
A	*Santa Cruz*	6 May	20	28	41	35	18	< 8-9	68 (126)
B	*Mormac Argo*	5-6 May	21	20	38	29	20	< 9-11	65 (120)
C	*Santa Cruz*	11-12 June	23	32	49	45	23	< 9-13	100 (185)
D	*Mormac Rigel*	14 Aug.	25	40	55	50	23	< 9-13	53 (98)
E	*Santa Cruz*	3-4 Sept.	27	45	70	50	19	< 9-14	90 (167)
F	USCGC *Taney*	29-30 Sept.	28	40	55	50	15	< 12-15	15 (28)
G	*Export Defender*	1 Oct.	29	40	63	60	22	< 12-16	29 (54)
H	*Mormac Rigel*	3 Oct.	30	34	99	72	30	< 11-14	110 (203)
I	*Santa Cruz*	9-10 Oct.	31	45	70	50	20	< 12-14	75 (139)

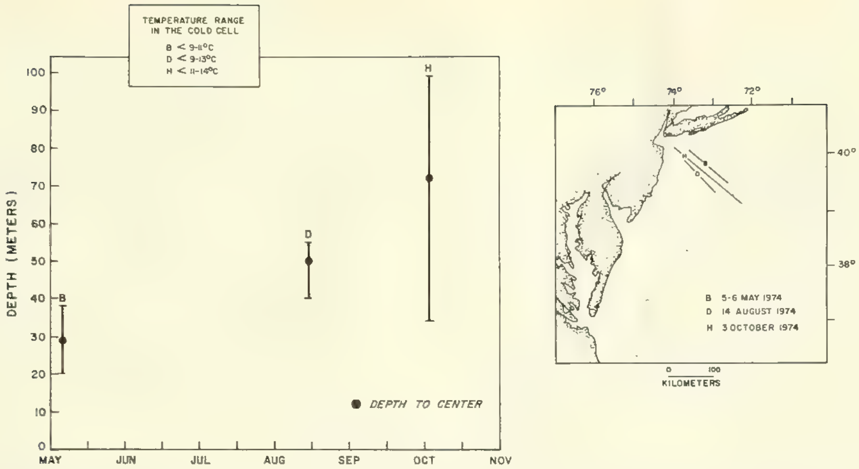

Figure 2.—Variations in cold cell temperature and depth along the MORMAC transect—May, August, and October of 1974.

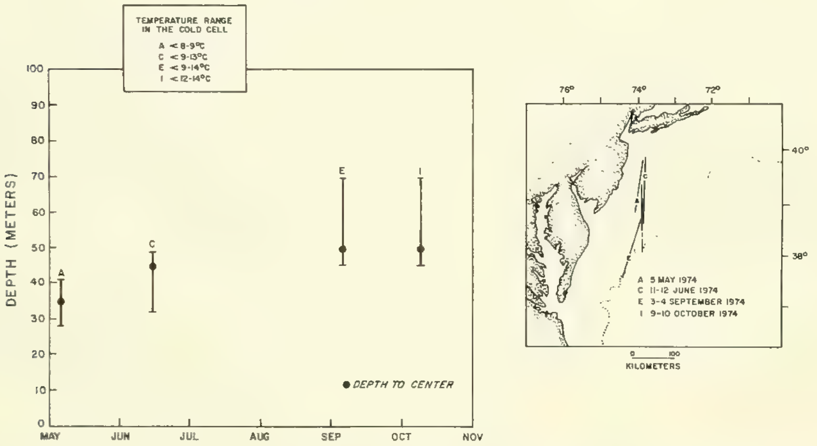

Figure 3.—Variations in cold cell temperature and depth along the *Santa Cruz* transect—May, June, September, and October of 1974.

20). Temperatures in the cell ranged from less than 8° to 9°C. The horizontal extent was 68 nautical miles (126 km) and the cell ranged from 28 to 41 m in bottom depth with a thickness of about 18 m at the center. By 11-12 June (Appendix Fig. 23) the outer fringes of the cell had warmed to 13°C and water with temperatures from 10° to 13°C had begun to move seaward over the shelf break. The bottom depth range at this time was 32-49 m. Within the cell, two separate parcels of water (< 9°C) were present between stations 26 and 30. On 3-4 September (Appendix Fig. 27) temperatures in the cell were in the 9°-14°C range and part of the cell had moved over the shelf break and extended to a depth of 70 m. The tonguelike shape of the 13° and 14°C isotherms showed the initial stages of a process called "calving" by Cresswell (1967) whereby a parcel of water separates from the parent mass and moves seaward. During 9-10 October (Appendix Fig. 31) the calving process was detected in an advanced stage. A mass of water with temperatures ranging from 12° to 14°C had separated from the cell on the shelf and was moving seaward over the shelf break. At this time, the cell extended to a maximum bottom depth of 70 m. These changes in temperature and depth are summarized in Figure 3.

Only two observations of the cold cell were made along the HOTEL transect, and these were closely spaced in time—29-30 September (Appendix Fig. 28) and 1 October (Appendix Fig. 29). Appendix Figure 28 shows temperatures ranging from less than 12° to 15°C in the cell over a bottom depth range of 40-55 m. The horizontal extent was only 15 nautical miles (28 km). Slightly further south, the temperatures ranged from less than 12° to 16° over a bottom depth range of 40-63 m (Appendix Fig. 29). Here the horizontal extent was 29 nautical miles (54 km). The changes in temperature and depth are summarized in Figure 4.

Several generalizations can be made from a composite plot of the changes in cold cell temperature and depth with Figure 5. Minimum temperatures within the cell remained low (8°-9°C) throughout the summer and

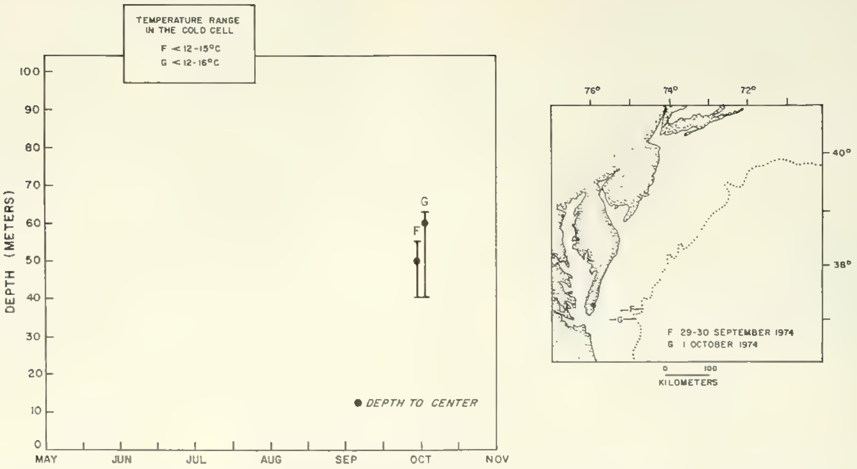

Figure 4.—Variations in cold cell temperature and depth along the HOTEL transect—September and October of 1974.

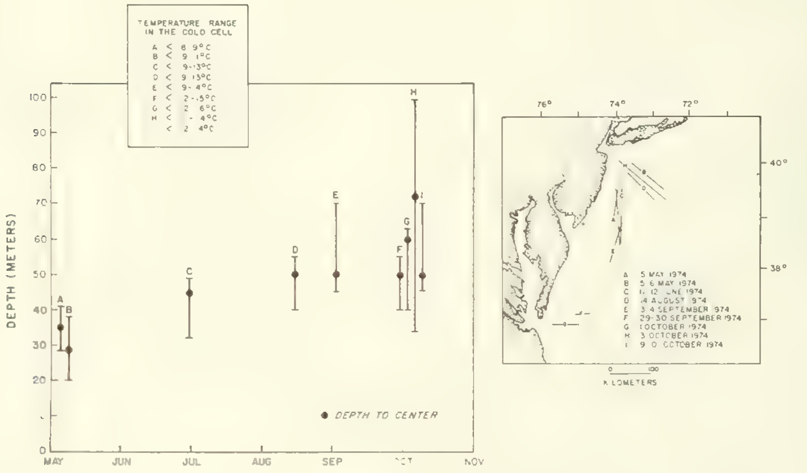

Figure 5.—Composite plot of cold cell temperature and depth—May, June, August, September, and October of 1974.

elevated temperatures were not observed until the end of September. The cold water was found in relatively shallow depths (20-40 m) in the spring, but as warming of shelf waters increased during the summer, the cell moved into deeper water. Observations made in the fall also indicated that the cell covered a greater depth range than in the spring. There seemed to be an increase in the minimum cell temperature from north to south, but there were not sufficient data to separate geographic variations from those caused by seasonal changes. A more detailed analysis would require more frequent observations made at regular intervals.

Gulf Stream.—Considerable attention has been focused on fluctuations in the position of the Gulf Stream. In addition to shipboard observations of temperature and salinity, satellite and aircraft observations of surface temperature are being used to differentiate between water masses. Because the SOOP transects intersect the Gulf Stream at discrete points with considerable spatial and temporal separation, complete coverage of the Gulf Stream and associated features by this means is impossible. However, when correlated with the satellite observations the transect data provide a source of ground truth for the remote sensors, as well as valuable subsurface information for investigators involved in study of the Gulf Stream system and other water masses.

During 1974, SOOP transects crossed the Gulf Stream 12 times. These crossings are summarized in Figures 6-9 and Table 5. Gulf Stream crossings were identified by the strong horizontal gradients shown on vertical temperature sections and positions of the North Wall were determined by using the 15°C isotherm at 200 m (Worthington 1964).

Both *The Gulf Stream Monthly Summary* and the NESS Experimental Gulf Stream Analysis (N-69) charts provide information about fluctuations in the Gulf Stream position. The information provided in these publications gives more complete and synoptic coverage over the entire Gulf Stream system than is possible through

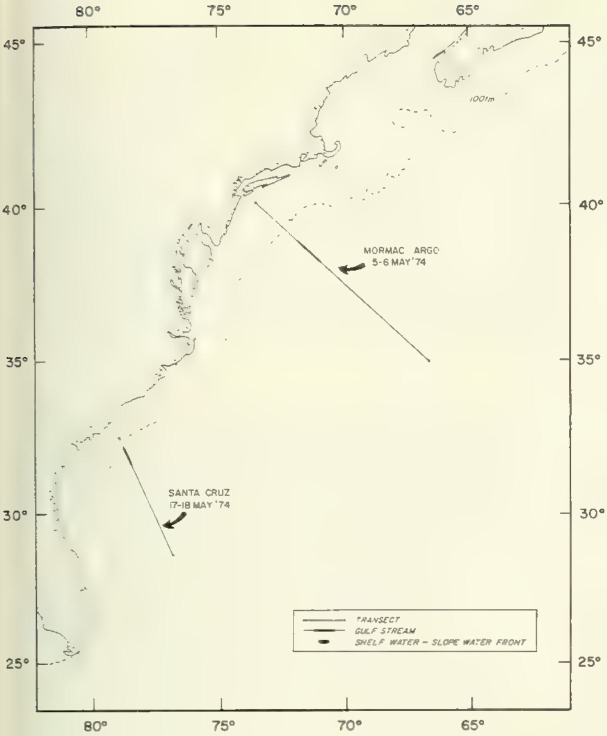

Figure 6.—Gulf Stream crossings—May 1974.

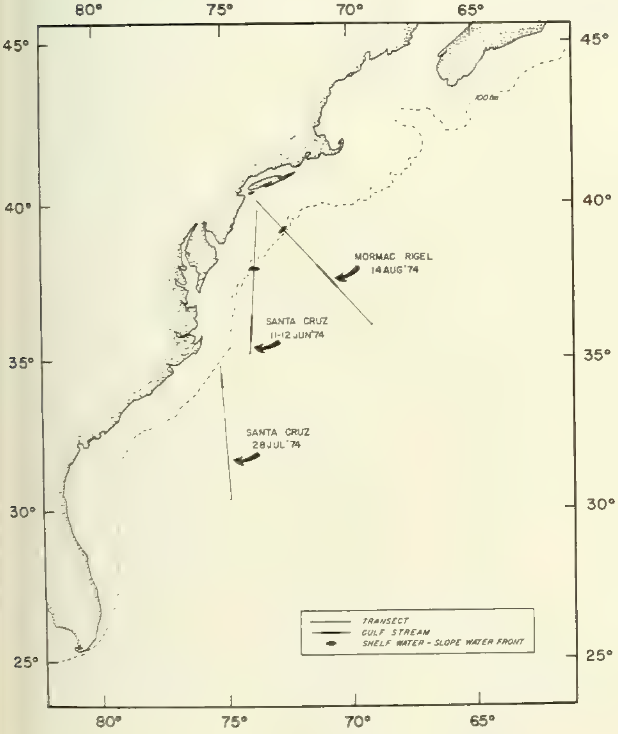

Figure 7.—Gulf Stream crossings and Shelf Water-Slope Water front positions—June-August 1974.

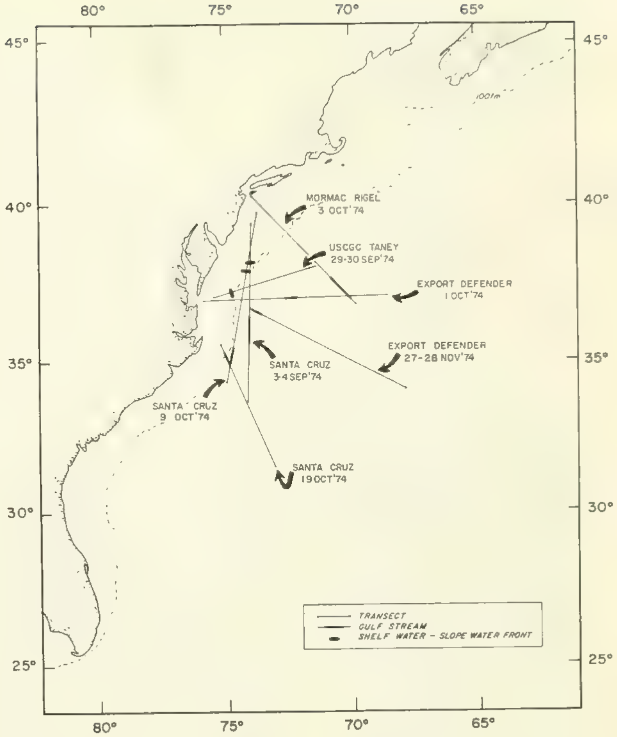

Figure 8.—Gulf Stream crossings and Shelf Water-Slope Water front positions—September-November 1974.

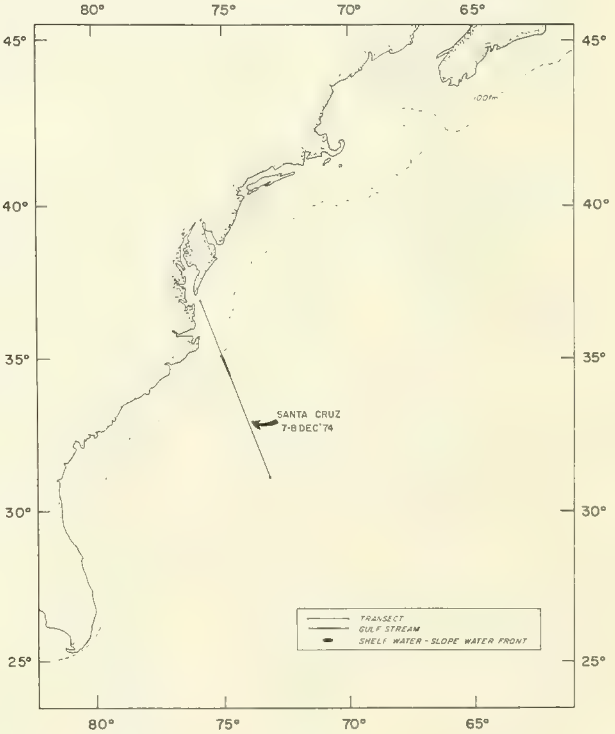

Figure 9.—Gulf Stream crossings—December 1974.

Table 5.—Gulf Stream crossings by SOOP vessels in 1974.

Appendix figure	Ship	Date	Position (lat., long.)
21	*Mormac Argo*	5-6 May	38°30′N, 71°12′W
22	*Santa Cruz*	17-18 May	31°48′N, 79°06′W
23	*Santa Cruz*	11-12 June	38°12′N, 73°57′W
24	*Santa Cruz*	28 July	34°48′N, 75°24′W
25	*Mormac Rigel*	14 Aug.	37°42′N, 70°48′W
27	*Santa Cruz*	3-4 Sept.	35°30′N, 75°00′W
29	*Export Defender*	1 Oct.	36°42′N, 72°18′W
30	*Mormac Rigel*	3 Oct.	37°30′N, 71°00′W
31	*Santa Cruz*	9-10 Oct.	36°12′N, 74°12′W
32	*Santa Cruz*	19 Oct.	35°00′N, 75°00′W
34	*Export Defender*	27-28 Nov.	36°00′N, 74°00′W
35	*Santa Cruz*	7-8 Dec.	36°00′N, 75°18′W

SOOP transects. However, since the N-69 charts are derived solely from remote sensing of sea surface temperatures and *The Gulf Stream Monthly Summary* is at least partially dependent upon these data, the patterns shown by these publications may not be as accurate as those portrayed from subsurface temperature data. The information collected by the SOOP affords an excellent source with which these data can be verified.

Table 6 shows the Gulf Stream positions as determined from each source. In each case, the distance has been measured along identical bearing lines and this distance converted to nautical miles. Several sources of error were apparent. The inconsistent quality of reproduction of N-69 charts and the distortion introduced by photocopying lead to some uncertainty in measurements. In addition, some interpolation was necessary to locate positions between stations on vertical sections. Interpolation was also necessary to determine positions during mid-month from *The Gulf Stream Monthly Summary* because positions were given only at the beginning and end of the month. An estimate of these errors accompanies each measurement.

Within the estimated range of measurement errors, the sources agreed closely on the positions of the Gulf Stream North Wall. Only in May was there a significant difference in the measurements. The distance offshore to the North Wall measured from *The Gulf Stream Monthly Summary* was about 40 nautical miles greater than the distance determined from SOOP data when superimposed on the N-69 charts.

Eddies.—From analysis of the vertical sections contained in this report, four Gulf Stream eddies were detected during 1974 (see Table 7 and Fig. 10). Eddy #1 (Appendix Fig. 19) was crossed by *Santa Cruz* on 5-6 May and was centered at station 7 (lat. 32°00′N, long. 75°00′W). The sloping of the isotherms indicated an asymmetrical cold core eddy, possibly becoming entrained in the Gulf Stream. *The Gulf Stream Monthly Summary* (April) showed an eddy centered at lat. 33°00′N, long. 74°00′W on 30 March 1974. Since the eddy was not shown in the May issue, it may have become entrained during the interval. This eddy was not shown on the N-69 charts.

On 5-6 May (Appendix Fig. 21) *Mormac Argo* crossed a cyclonic, cold core eddy (Eddy #2) that was centered around station 8 (lat. 36°00′N, long. 68°00′W). The structure of the eddy was evident to a depth of about 600 m and the width at the surface where transected was approximately 145 nautical miles (269 km). The May issue

Table 6.—Comparison of Gulf Stream position in 1974 as located by SOOP, NESS N-69 charts, and *The Gulf Stream Monthly Summary*.

			N-69 Charts		Gulf Stream	
Appendix figure/date	SOOP bearing line	Distance nm (km)	Date/Bearing line	Distance nm (km)	Date/Bearing line	Distance nm (km)
21 5-6 May	Sandy Hook 130°	171±12 (317±22)	4-7 May Sandy Hook 130°	155±35 (287±65)	May Sandy Hook 130°	235±10 (435±19)
22 17-18 May	Charleston 147°	87±10 (161±19)	Cloud Cover	—	May Charleston 147°	34±12 (156±22)
23 11-12 June	Cape Charles 124°	118±15 (219±28)	6-10 June Cape Charles 124°	90±15 (167±28)	June Cape Charles 124°	100±18 (185±33)
24 28 July	Cape Charles 170°	140±25 (259±46)	Cloud Cover	—	July Cape Charles 170°	144±10 (267±19)
25 14 Aug.	Sandy Hook 137°	222±15 (411±28)	15-20 Aug. Sandy Hook 137°	225±10 (417±19)	August Sandy Hook 137°	215±24 (398±44)
27 3-4 Sept.	Cape Charles 161°	132±15 (245±28)	4-10 Sept. Cape Charles 161°	120±10 (222±19)	September Cape Charles 161°	115±10 (213±19)
29 1 Oct.	Cape Charles 95°	174± 6 (322±11)	27 Sept.-1 Oct. Cape Charles 95°	165±15 (306±28)	October Cape Charles 95°	150±10 (278±19)
30 3 Oct.	Sandy Hook 137°	225± 6 (417±11)	4-6 Oct. Sandy Hook 137°	230±20 (426±37)	October Sandy Hook 137°	210±10 (389±19)
31 9-10 Oct.	Cape Charles 128°	120±20 (222±37)	11 Oct. Cape Charles 128°	95±10 (176±19)	October Cape Charles 128°	120±10 (222±19)
32 19 Oct.	Cape Charles 161°	120±10 (222±19)	18-22 Oct. Cape Charles 161°	120±15 (222±28)	October Cape Charles 161°	125±12 (232±22)
34 27-28 Nov.	Cape Charles 140°	102± 6 (189±11)	21-24 Nov. Cape Charles 140°	91±15 (169±28)	November Cape Charles 140°	100±10 (185±19)
35 7-8 Dec.	Cape Charles 163°	100±50 (185±93)	5-10 Dec. Cape Charles 163°	135±12 (250±22)	December Cape Charles 163°	121±10 (224±19)

Table 7.—Gulf Stream eddies transected by SOOP vessels in 1974.

Eddy number	Appendix figure/ Date	Location of center (lat., long.)	Approximate surface diameter nm (km)	Maximum observed depth (m)	Direction of rotation
1	19 5 May	32°N, 75°W	165 (306)	650	Cyclonic
2	21 5-6 May	36°N, 68°W	145 (269)	500	Cyclonic
3	33 20 Oct.	37°N, 74°W	90 (167)	450	Anticyclonic
4	35 7-8 Dec.	32°N, 73°30′W	150 (278)	660	Cyclonic

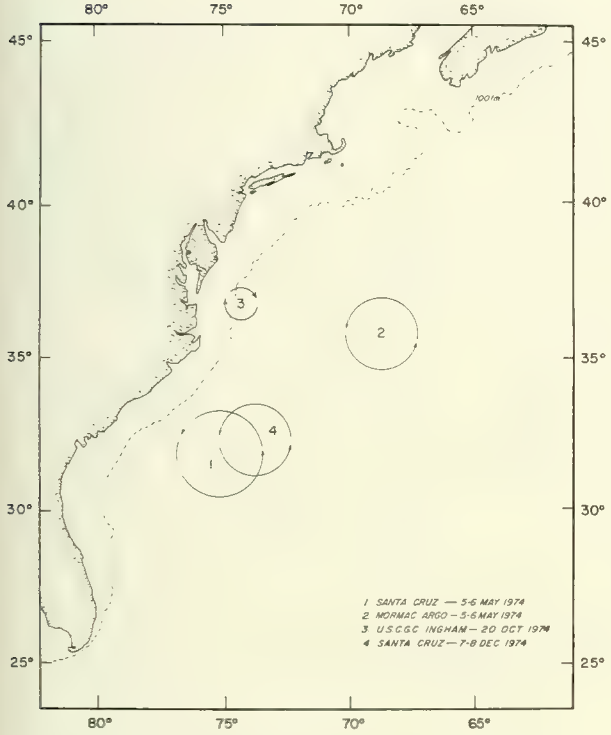
80°
75°
70°
65°
45°
40°
35°
30°
25°
100 m
1
2
3
4
1 SANTA CRUZ — 5-6 MAY 1974
2 MORMAC ARGO — 5-6 MAY 1974
3 U.S.C.G.C INGHAM — 20 OCT 1974
4 SANTA CRUZ — 7-8 DEC 1974

Figure 10.—Gulf Stream eddies surveyed during 1974.

of *The Gulf Stream Monthly Summary* showed a cyclonic eddy with a width of about 80 nautical miles (148 km) centered at a position of lat. 36°30′N, long. 68°00′W, which corresponded closely to the position of Eddy #2. No correlation could be made with the NESS N-69 charts of 4-7 May 1974 because of heavy cloud cover in the study area. However, the 14 May 1974 N-69 charts showed a cold-water intrusion in this area. Comparison of SOOP original XBT traces with other traces shown in *The Gulf Stream Monthly Summary* revealed reasonable similarity; it was concluded that Eddy #2 was the same eddy depicted in the May summary.

Appendix Figure 21 also showed another unusual feature. An unusually strong thermal gradient (surface temperatures changed from 23° to 20°C over a distance of 15 nautical miles or 28 km) was present between stations 3 and 4. Similar fronts in the Sargasso Sea have been described by Katz (1969), Voorhis (1969), and Voorhis and Hersey (1964).

Eddy #3 (Appendix Fig. 33) was located by USCGC *Ingham* on 20 October 1974. This anticyclonic eddy was centered near lat. 37°N, long. 74°W with the characteristic downwarping of the isotherms being detectable between stations 3 and 7. An intrusion of warm water shown on the 23-28 October and 31 October-3 November N-69 charts could have been the result of this warm eddy moving into this region. However, no eddy was shown at this location in the October or November issues of *The Gulf Stream Monthly Summary*.

Eddy #4 (Appendix Fig. 35), a cold core, cyclonic eddy, was crossed by *Santa Cruz* on 7-8 December 1974. The maximum depth observed by XBT was 660 m, while the eddy center was located around lat. 32°00′N, long. 73°30′W (station 14). Sea surface temperatures were as much as 3°C lower than adjacent Gulf Stream waters, but no signature was detectable in the surface salinities. This eddy was apparently the same one that was monitored with neutrally buoyant floats by the U.S. Naval Oceanographic Office and surveyed on 11 December 1974 by P. L. Richardson aboard RV *Trident* (Gemmill 1974; Anonymous 1975; Gemmill and Cheney 1975).

Shelf Water-Slope Water front.—SOOP transects crossed the Shelf Water-Slope Water front five times during 1974. Determinations of frontal crossings were made primarily on the basis of subsurface temperature gradients shown on the vertical sections with additional supporting evidence being drawn from surface temperature and salinity gradients. A summary of these crossings is given in Table 8 and in Figures 6-9.

In order to provide a means of verification of the position of the front as determined from SOOP sections, comparisons have been made with NESS N-69 charts. After the position of the front was determined on the

Table 8.—Shelf Water-Slope Water front crossings by SOOP vessels in 1974.

Appendix figure	Ship	Date	Frontal position (lat., long.)
23	*Santa Cruz*	11-12 June	38°N, 71°48′W
25	*Mormac Rigel*	14 Aug.	39°42′N, 73°W
27	*Santa Cruz*	3-4 Sept.	38°N, 74°W
28	USCGC *Taney*	29-30 Sept.	37°N, 75°W
31	*Santa Cruz*	9-10 Oct.	38°18′N, 73°54′W

Table 9.—Comparison of position of Shelf Water-Slope Water front as detected by SOOP and N-69 charts.

Appendix figure	Date	SOOP bearing line	Distance nm (km)	Date	N-69 bearing line	Distance nm (km)
23	11-12 June	Cape Charles 53°	132±15 (245±28)	13-18 June	Cape Charles 53°	156±18 (289±33)
25	14 Aug.	Sandy Hook 141°	72±15 (133±28)	12 Aug.	Sandy Hook 141°	90±10 (167±19)
27	3-4 Sept.	Cape Charles 53°	108±12 (200±22)	Cloud cover in study area—no measurement possible		
28	29-30 Sept.	Cape Charles 86°	66±10 (122±19)	27 Sept.- 1 Oct.	Cape Charles 86°	66±12 (122±22)
31	9-10 Oct.	Cape Charles 53°	132±20 (245±37)	11 Oct.	Cape Charles 53°	102±10 (189±19)

SOOP sections, a bearing line was established to a nearby landmark. The distance in nautical miles was measured with a pair of dividers and an estimate of error was made. The position of the front was then measured along the same bearing line on the N-69 charts. These comparisons are shown in Table 9.

Within the estimated range of measurement error, the positions determined from the two sources agreed closely, suggesting that the methods currently used are reliable indicators of the frontal position.

ACKNOWLEDGMENTS

Appreciation is extended to the Maritime Academy Training representatives M. Chichurel and A. Finley in New York and D. Thompson in New Orleans, La. Their diligent efforts to place midshipmen on board ships that were scheduled to traverse preselected oceanic areas were instrumental to the success of this program. Also, thanks are extended to H. O. Travis and the National Maritime Research Center (NMRC) for their support in expanding the SOOP effort. In addition, thanks are extended to the Moore McCormack Lines and Grace Prudential Lines of New York and the Delta Steamship Company and Sea Land Shipping Lines of New Orleans. Finally, appreciation is accorded to the Marine Science Branch, Commander Atlantic Area, U.S. Coast Guard, and to the officers and crews of the USCGC *Ingham* and USCGC *Taney*.

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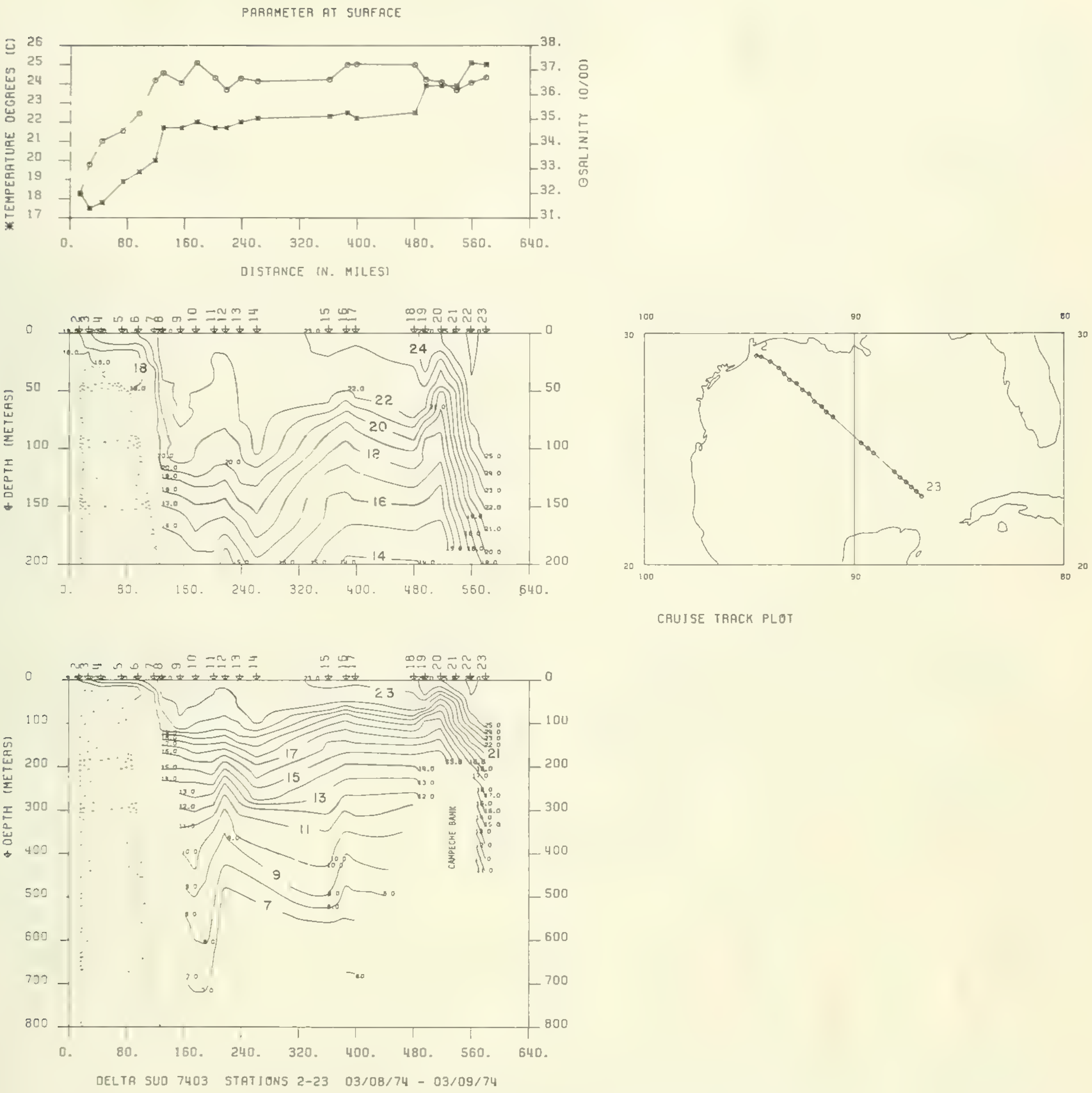
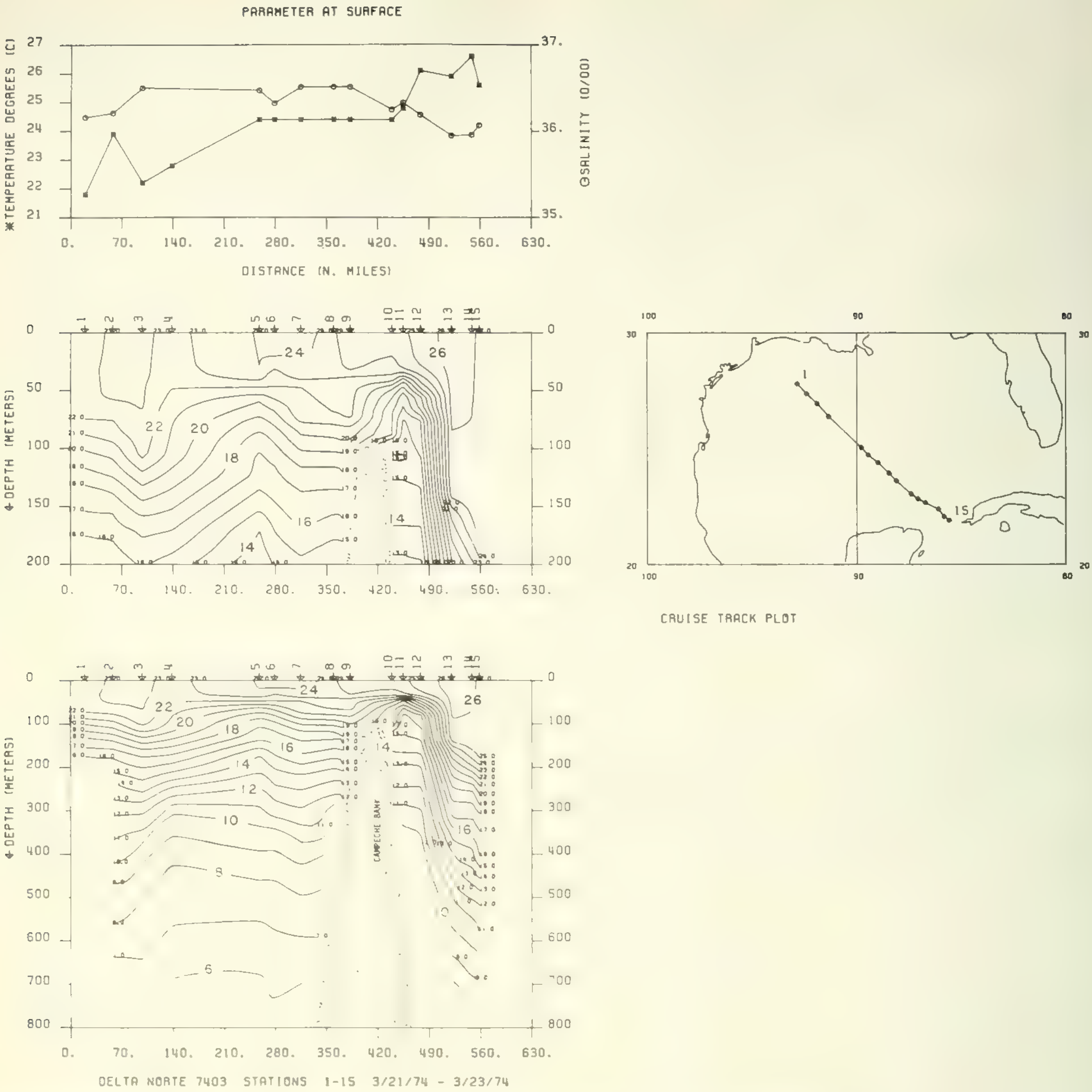
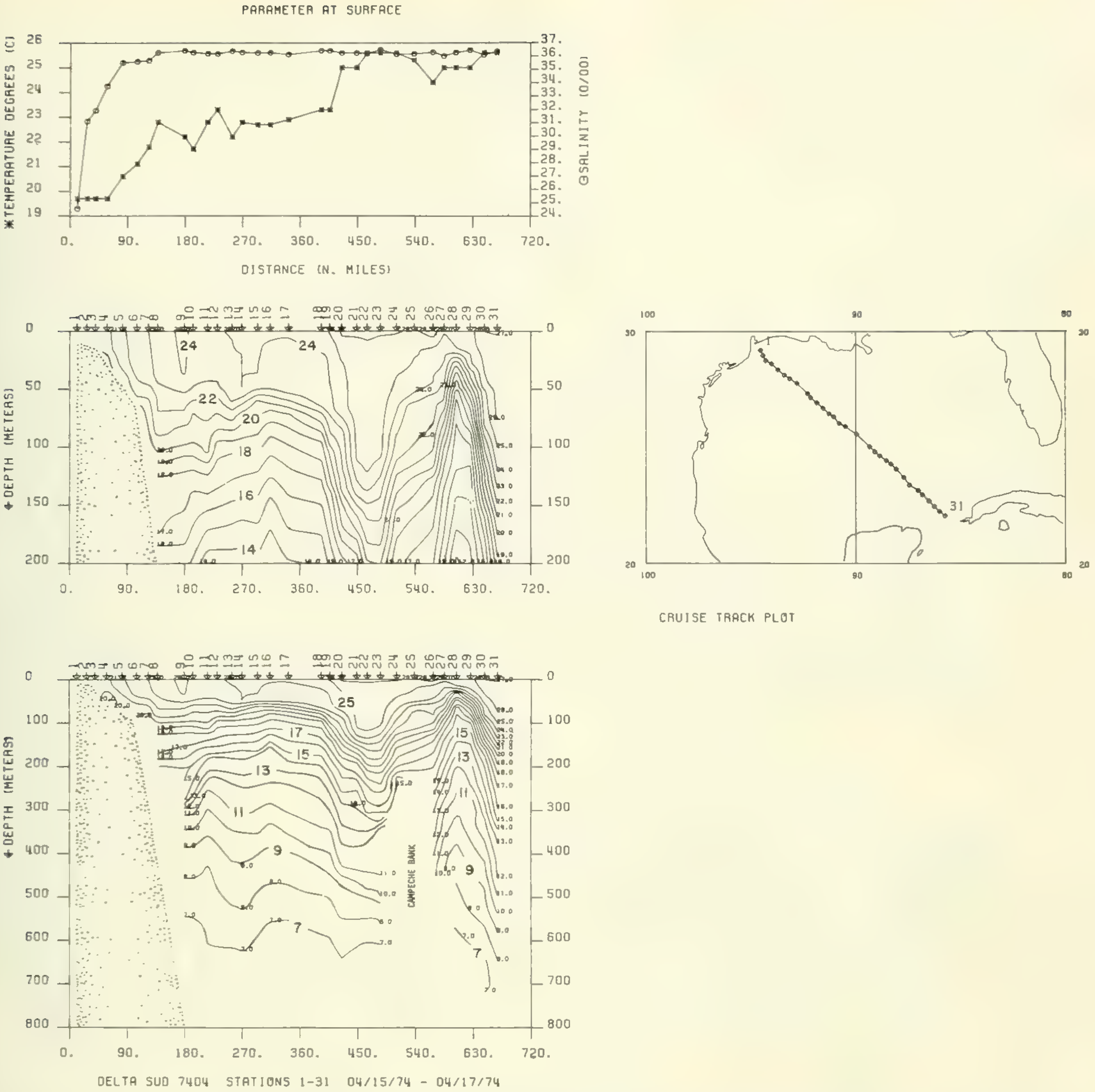


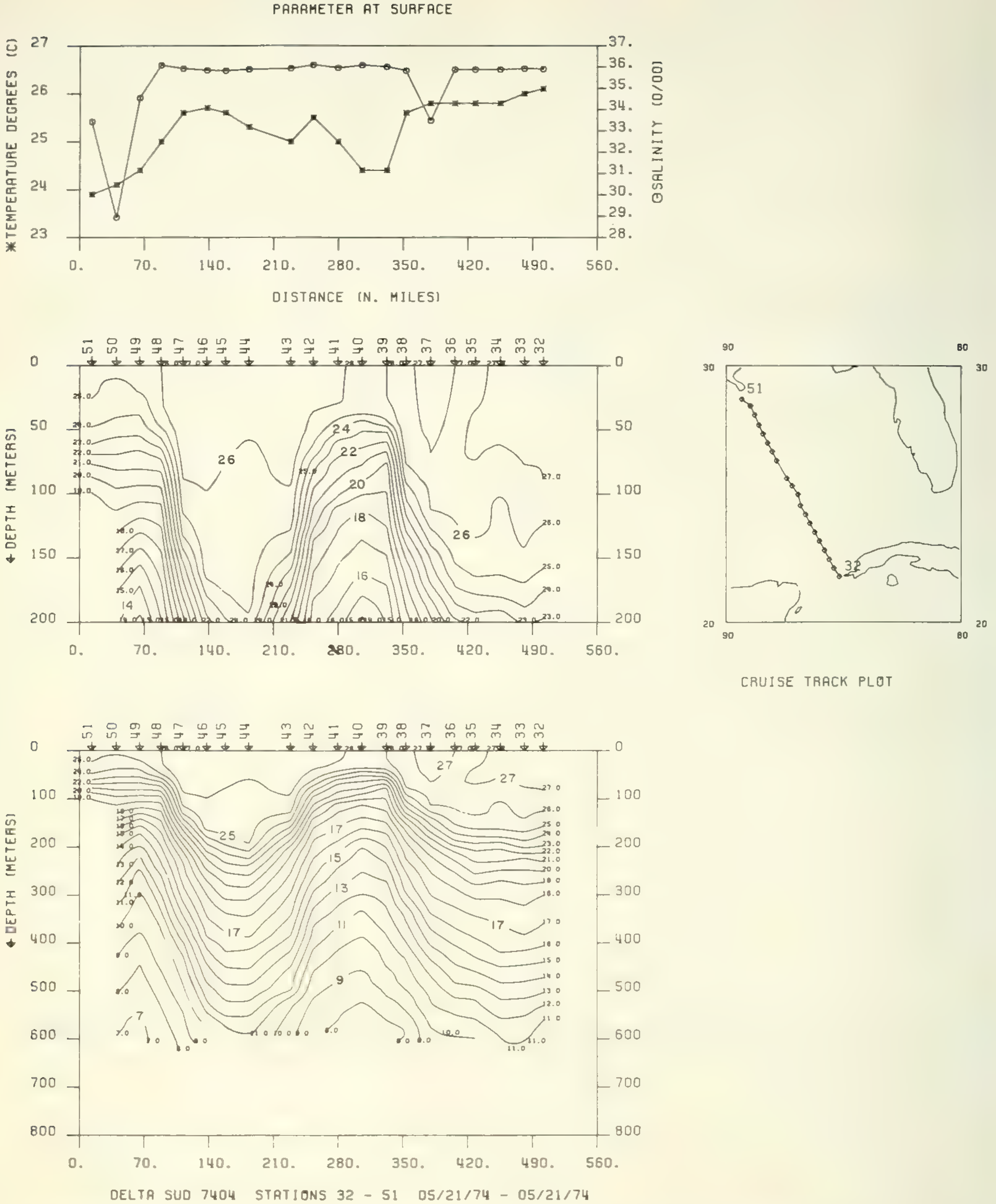
Appendix Figure 1.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—8-9 March 1974.



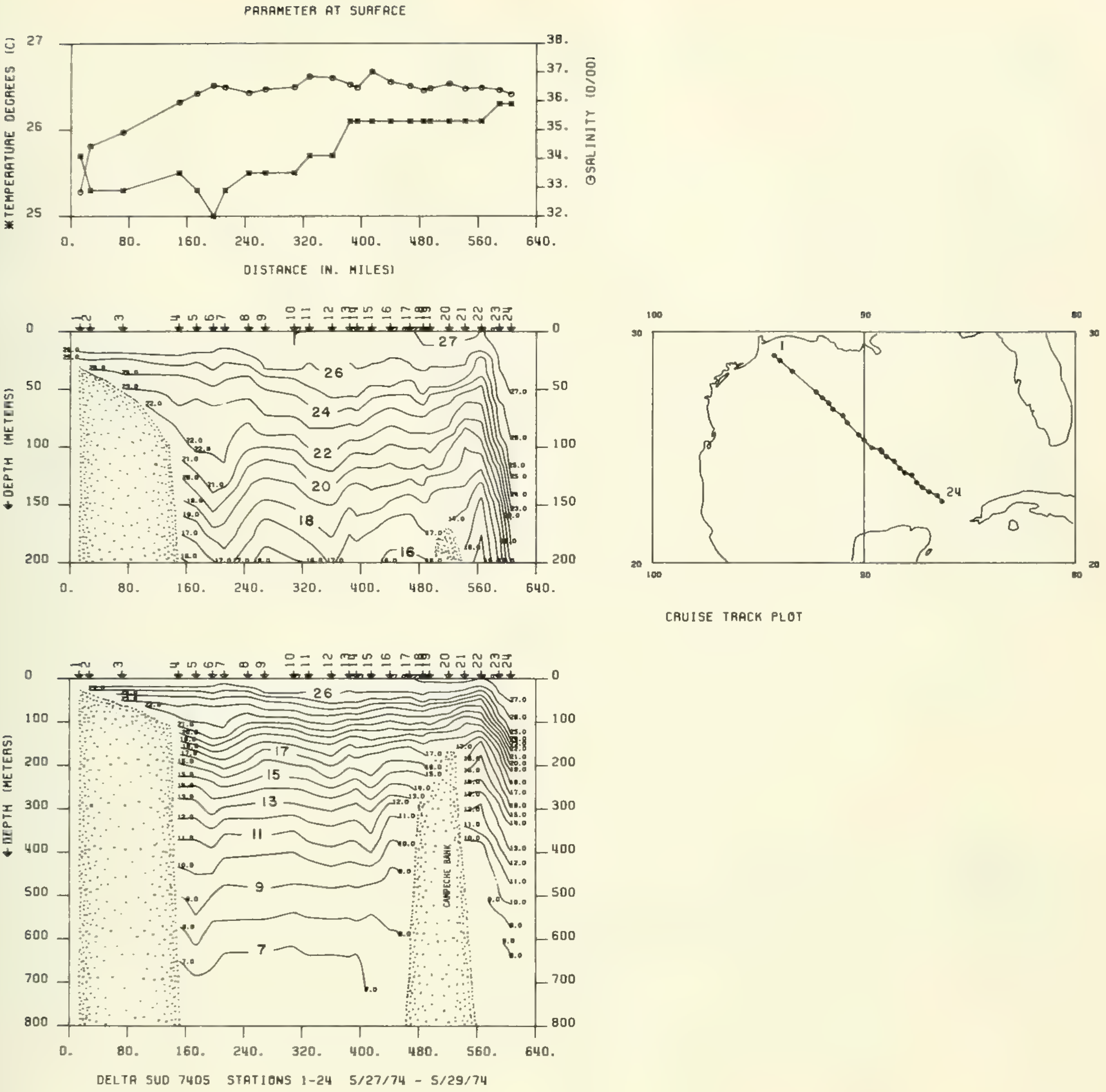
Appendix Figure 2.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Norte*—21-23 March 1974.



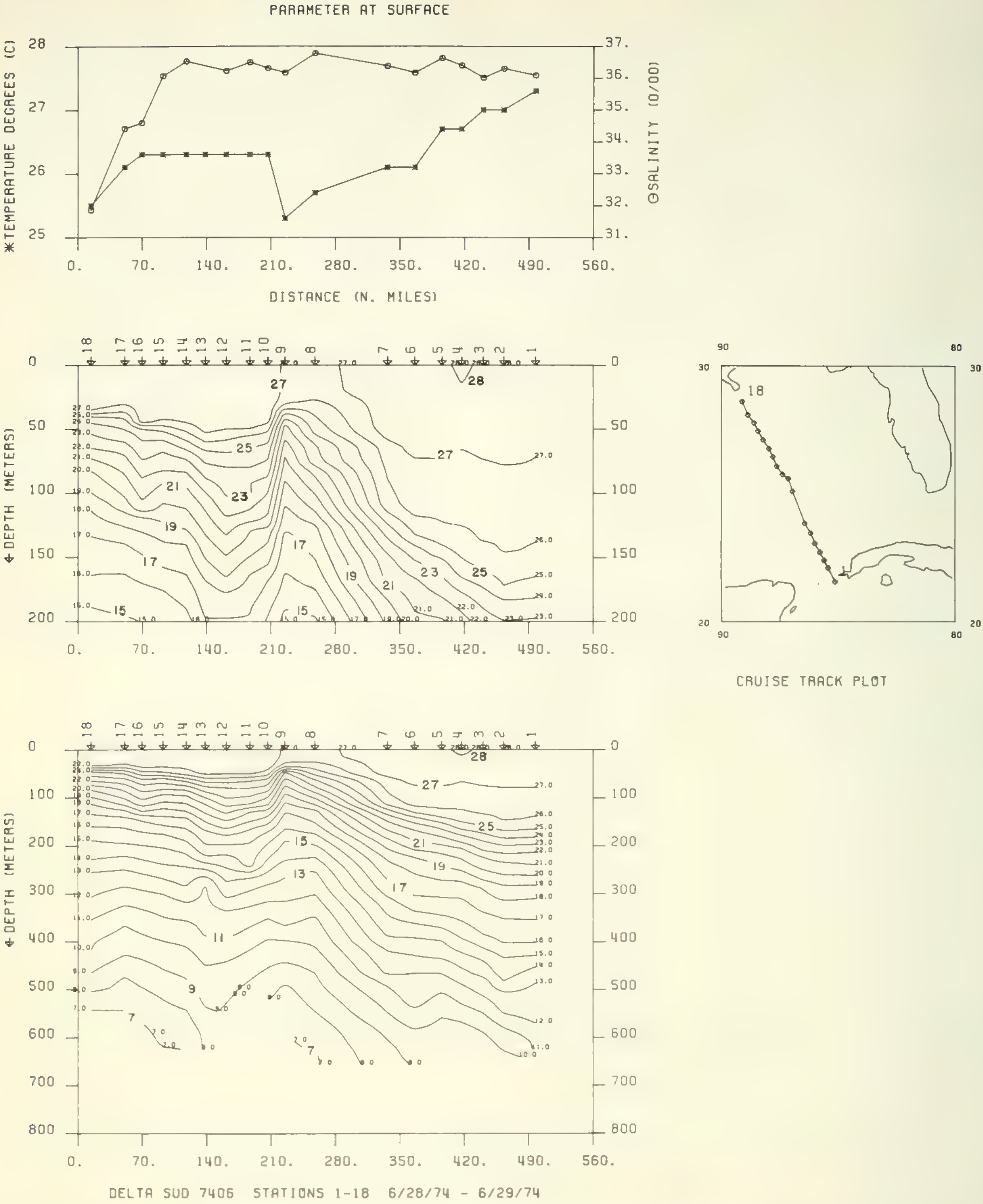
Appendix Figure 3.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—15-17 April 1974.



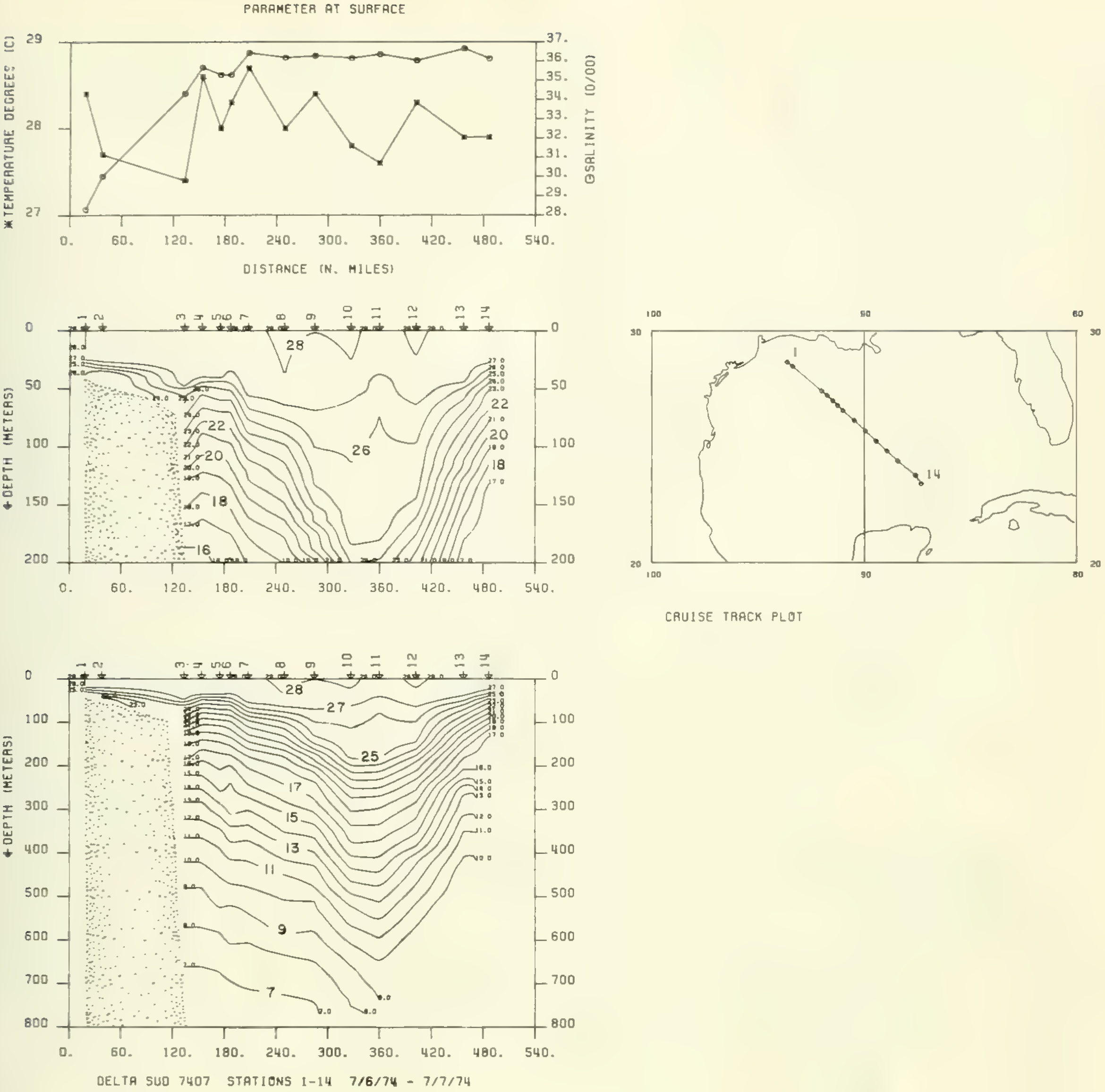
Appendix Figure 4.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—21 May 1974.



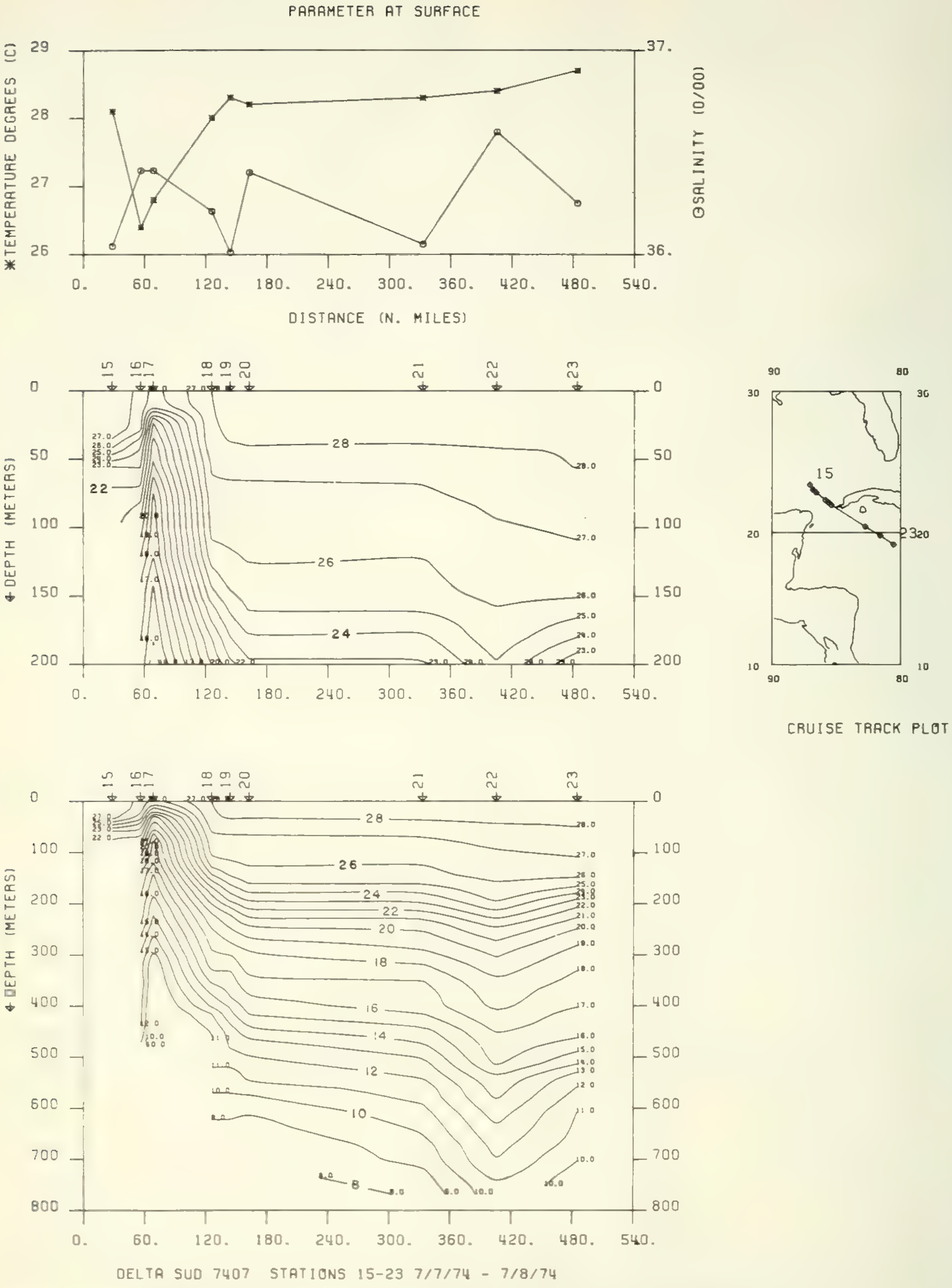
Appendix Figure 5.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—27-29 May 1974.



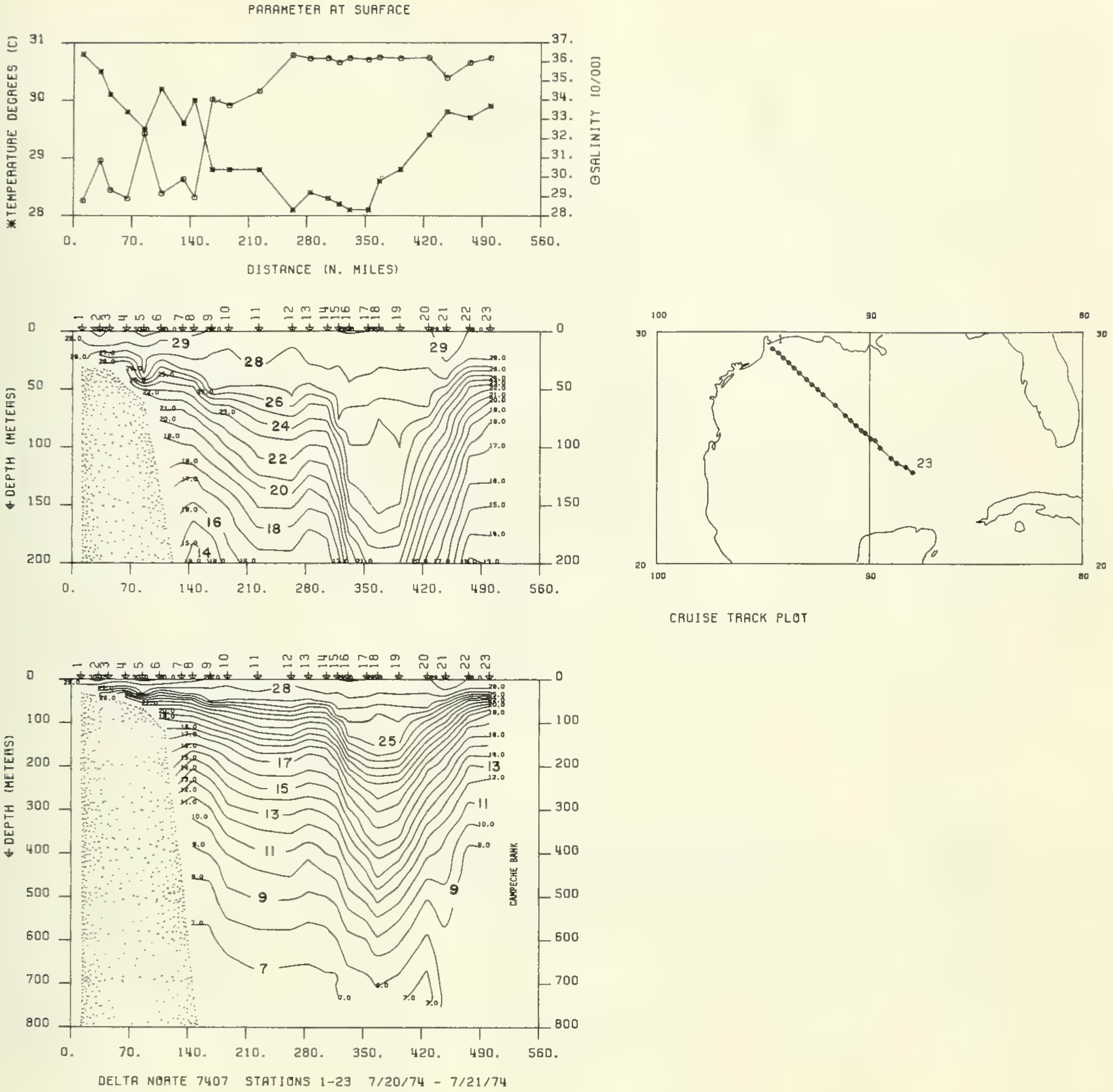
Appendix Figure 6.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—28-29 June 1974.



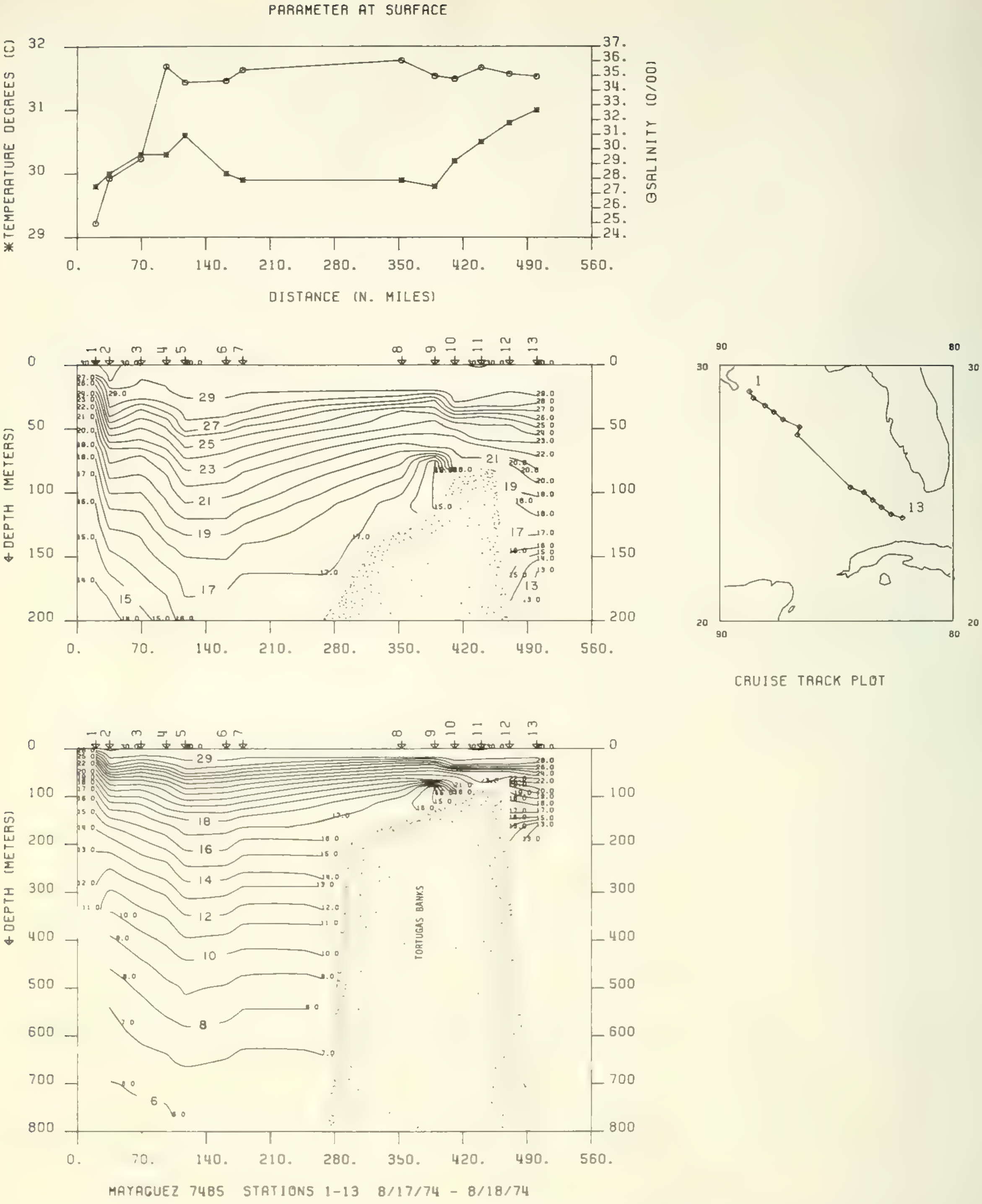
Appendix Figure 7.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—6-7 July 1974.



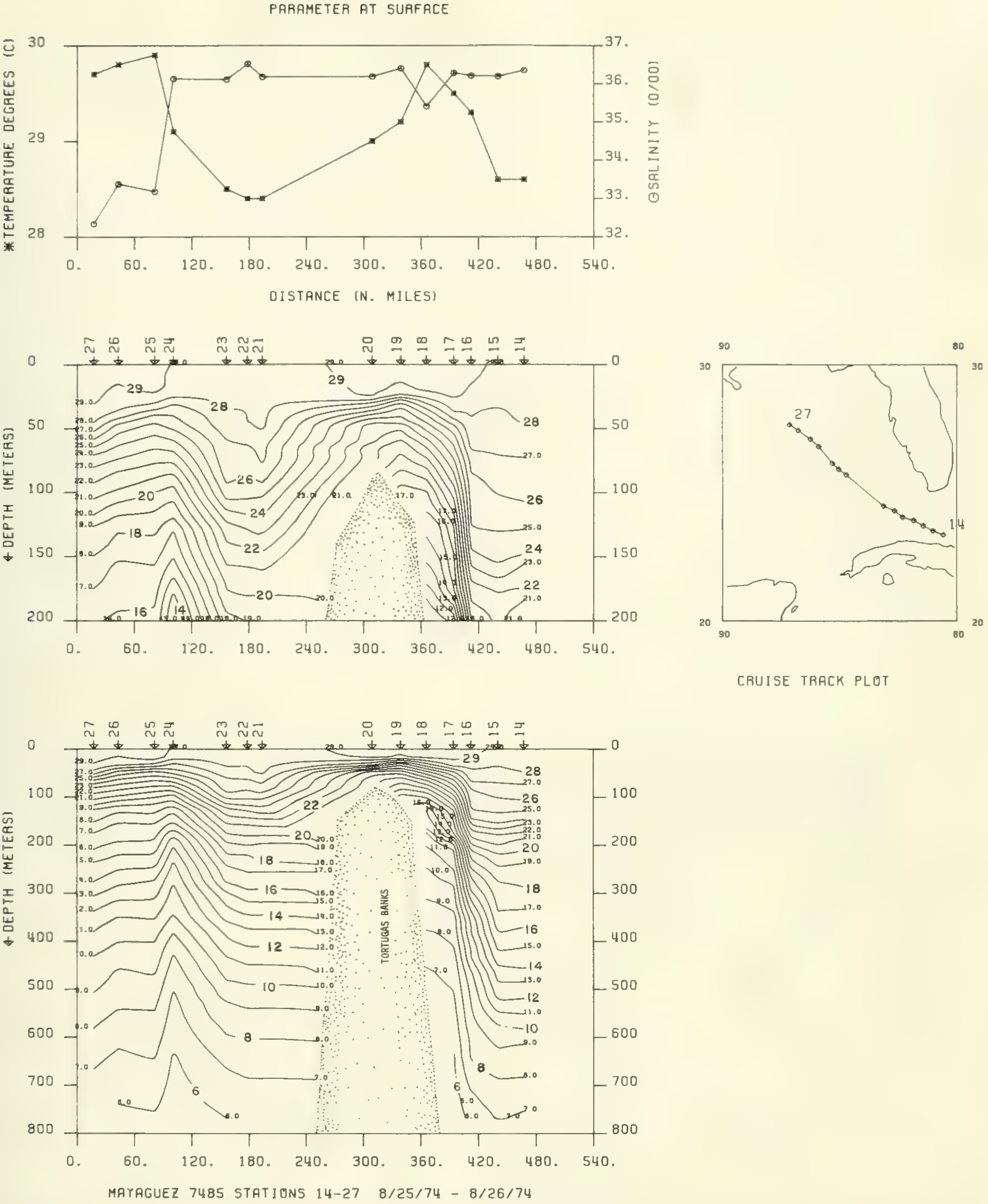
Appendix Figure 8.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—7-8 July 1974.



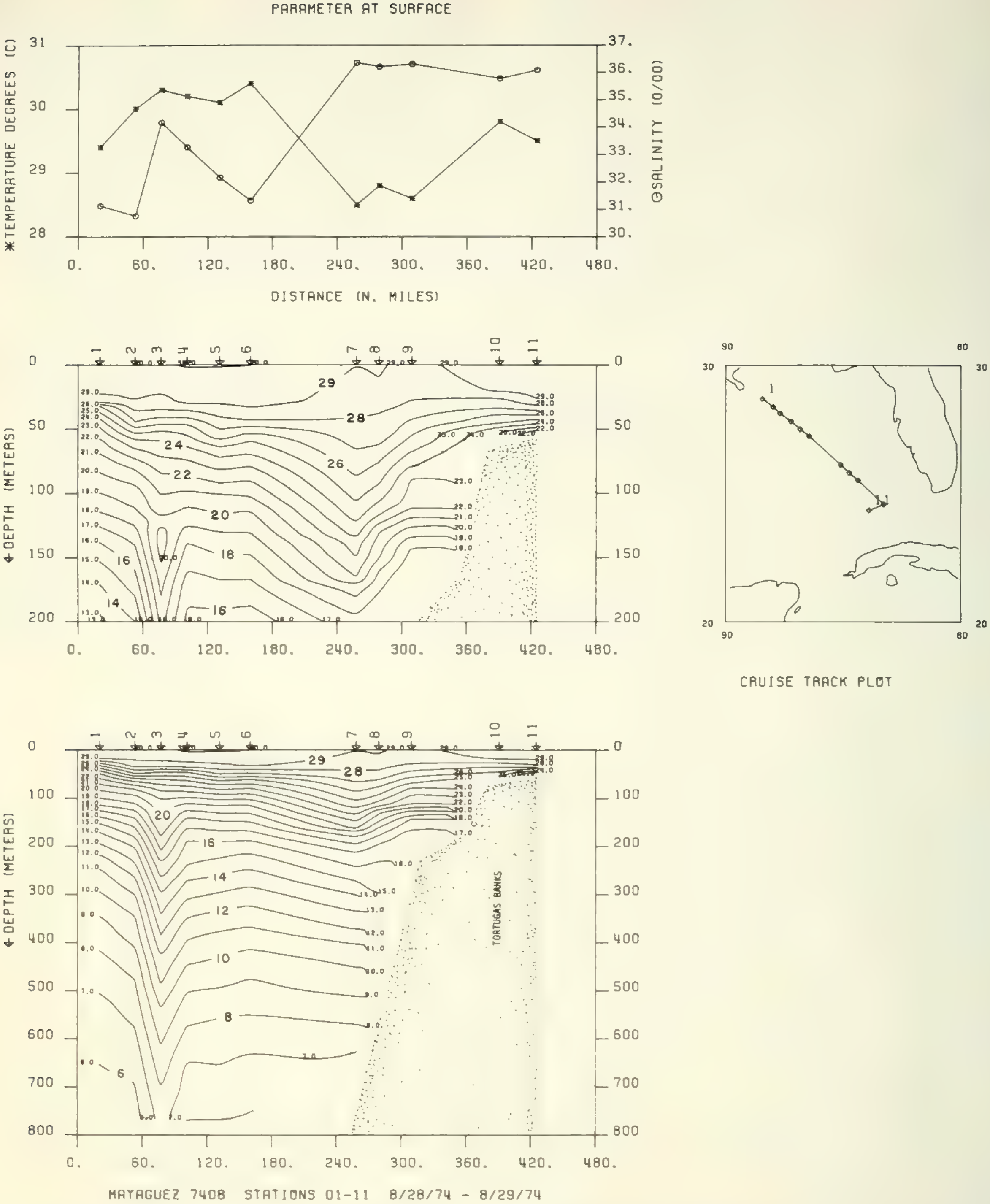
Appendix Figure 9.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/∘∘) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Norte*—20-21 July 1974.



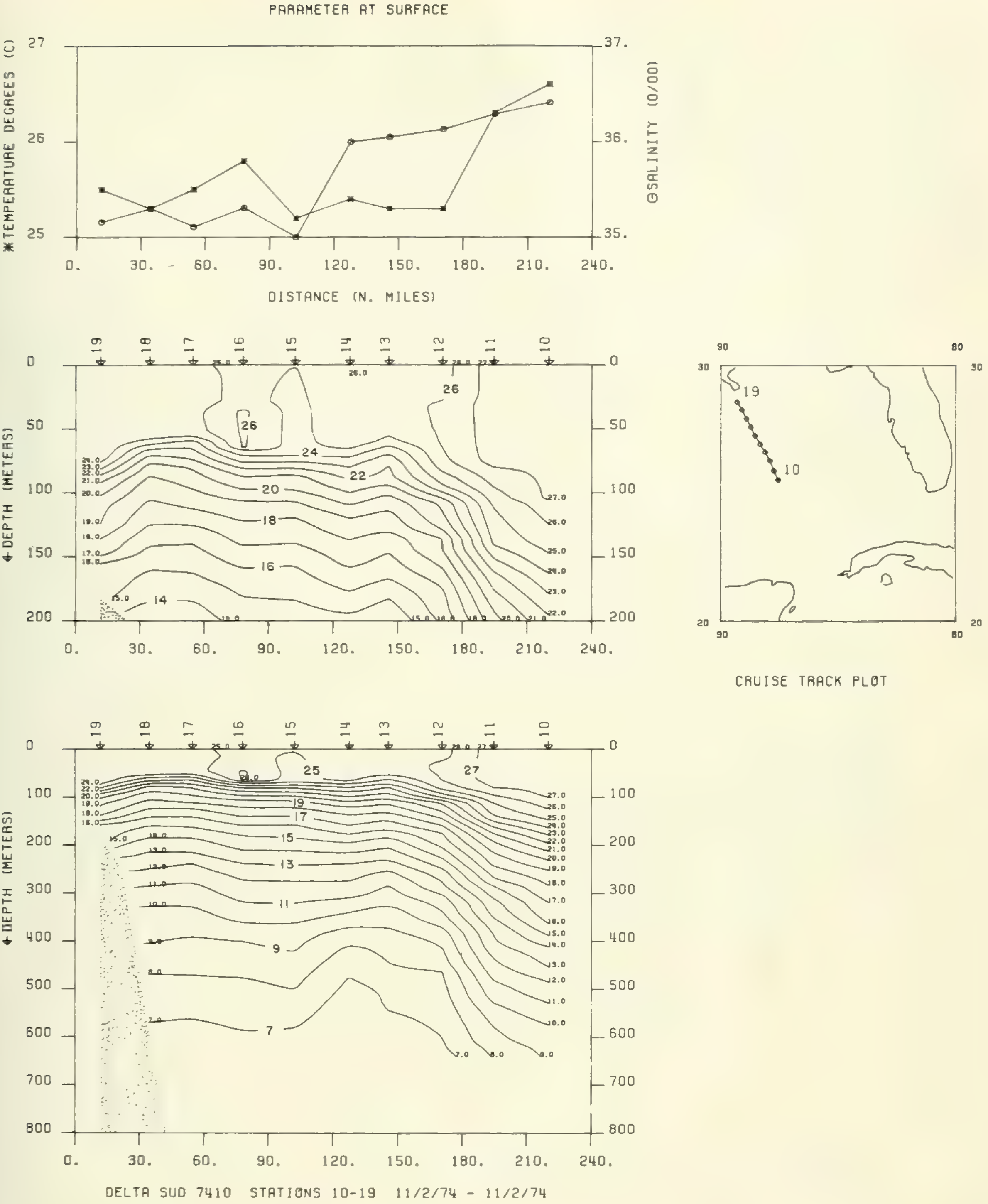
Appendix Figure 10.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mayaguez*—17-18 August 1974.



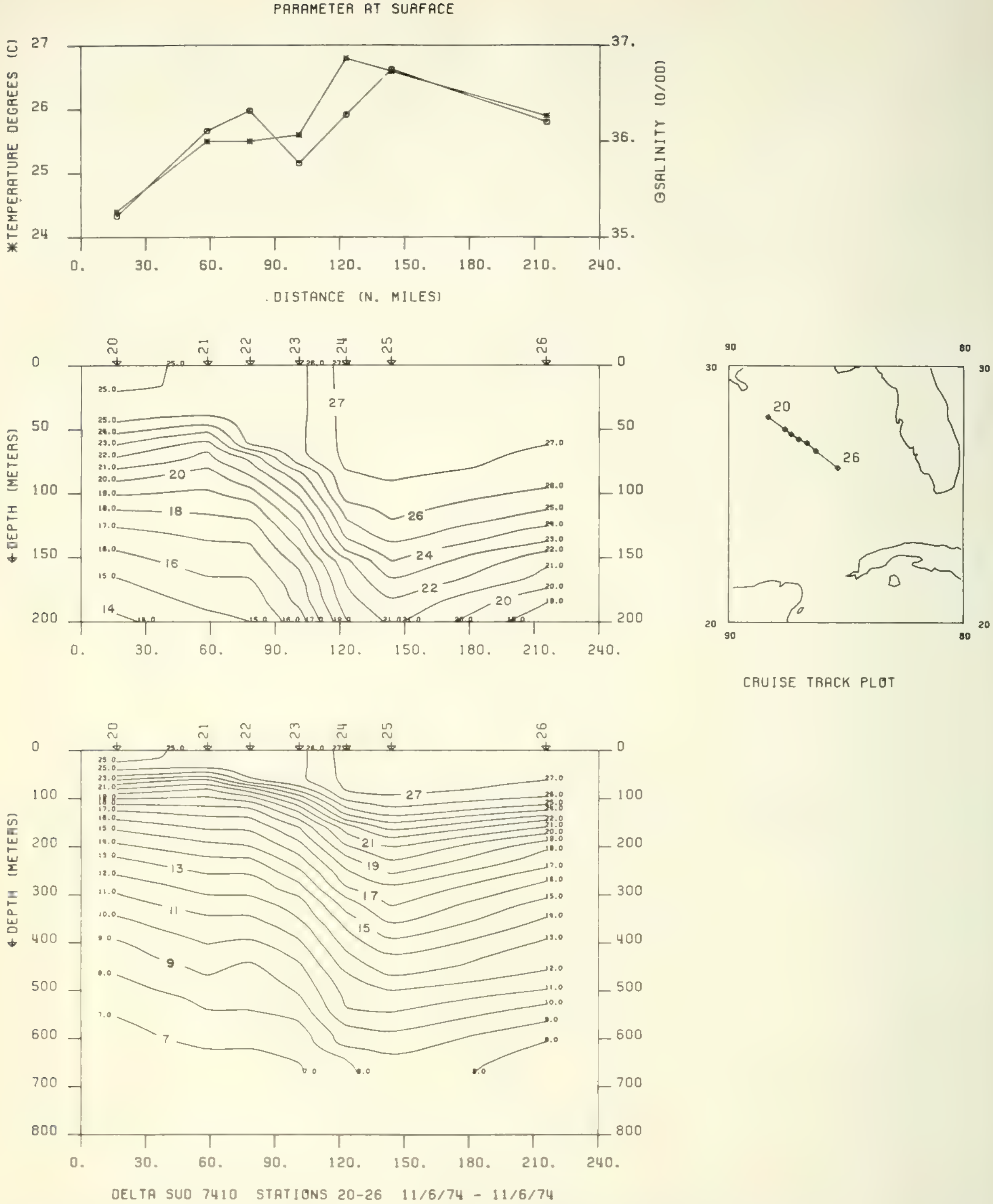
Appendix Figure 11.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mayaguez*—25-26 August 1974.



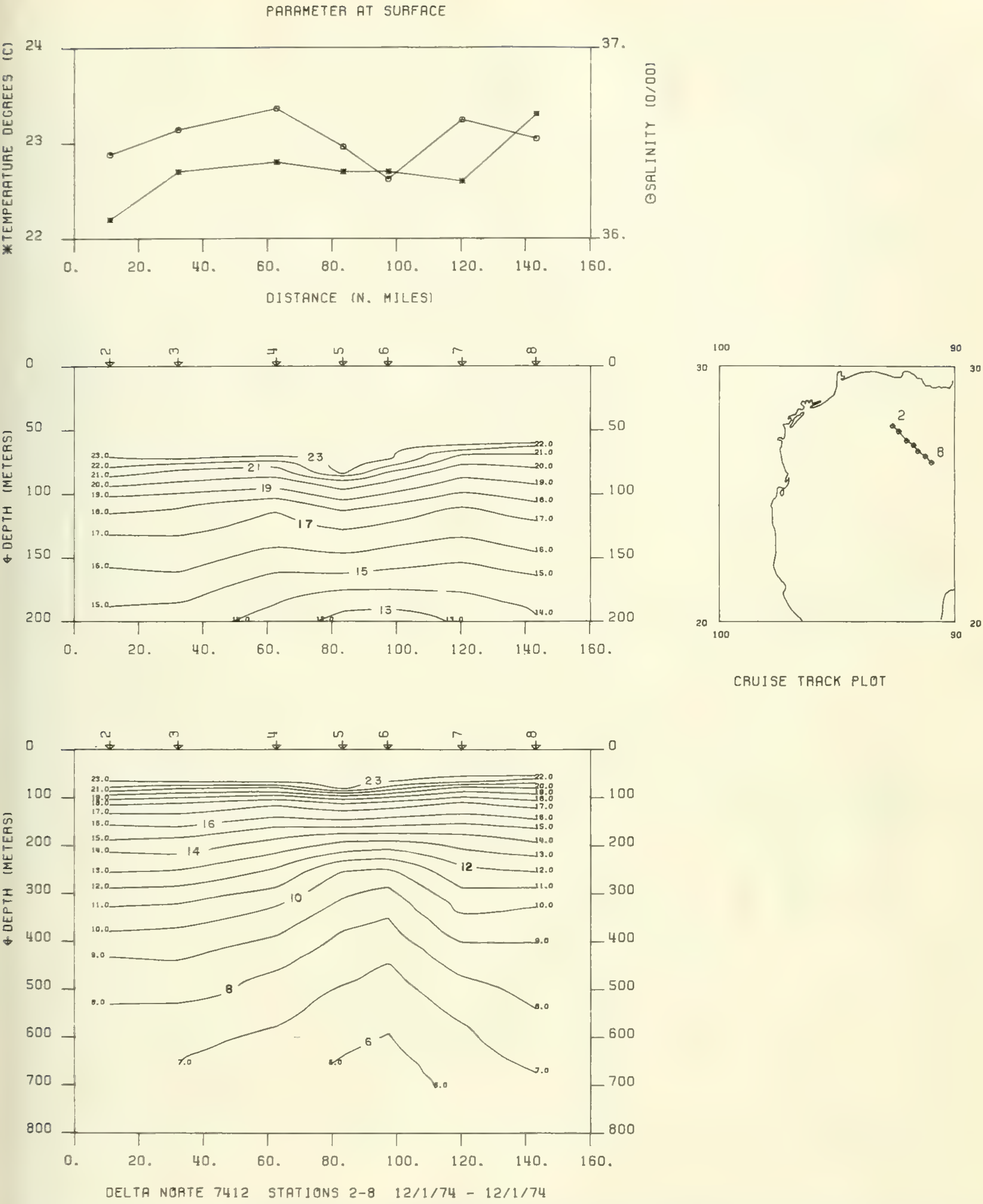
Appendix Figure 12.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mayaguez*—28-29 August 1974.



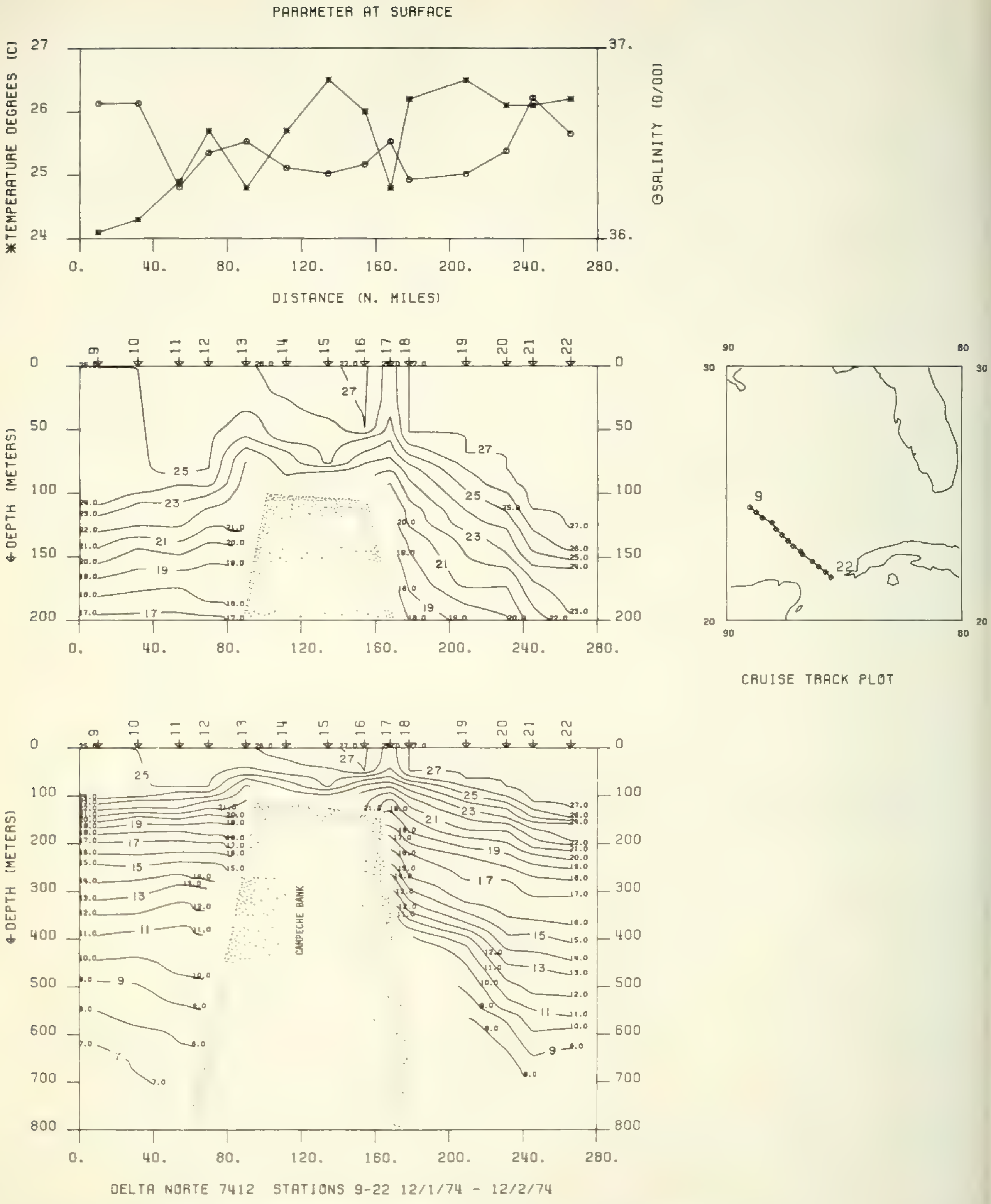
Appendix Figure 13.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—2 November 1974.



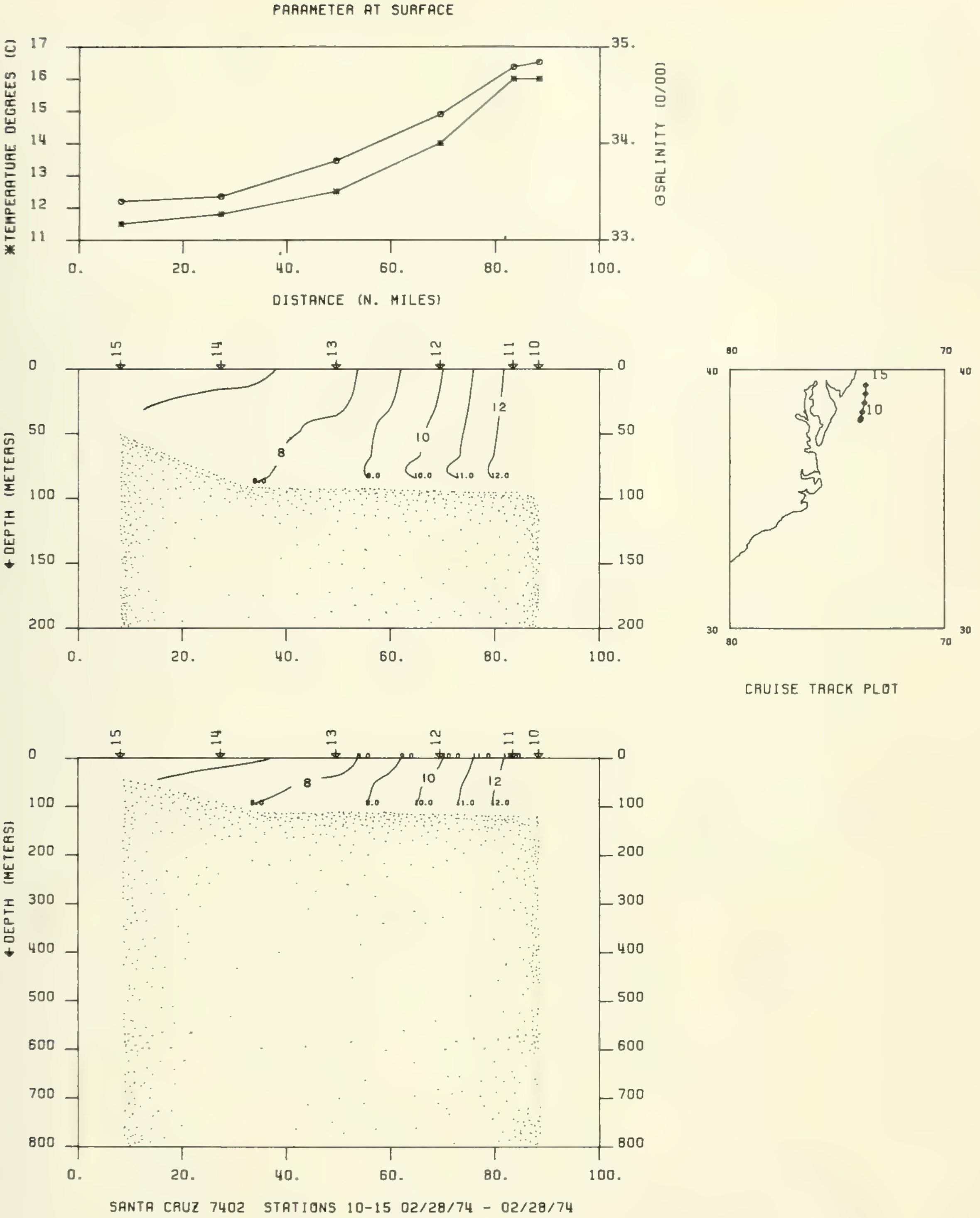
Appendix Figure 14.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Sud*—6 November 1974.



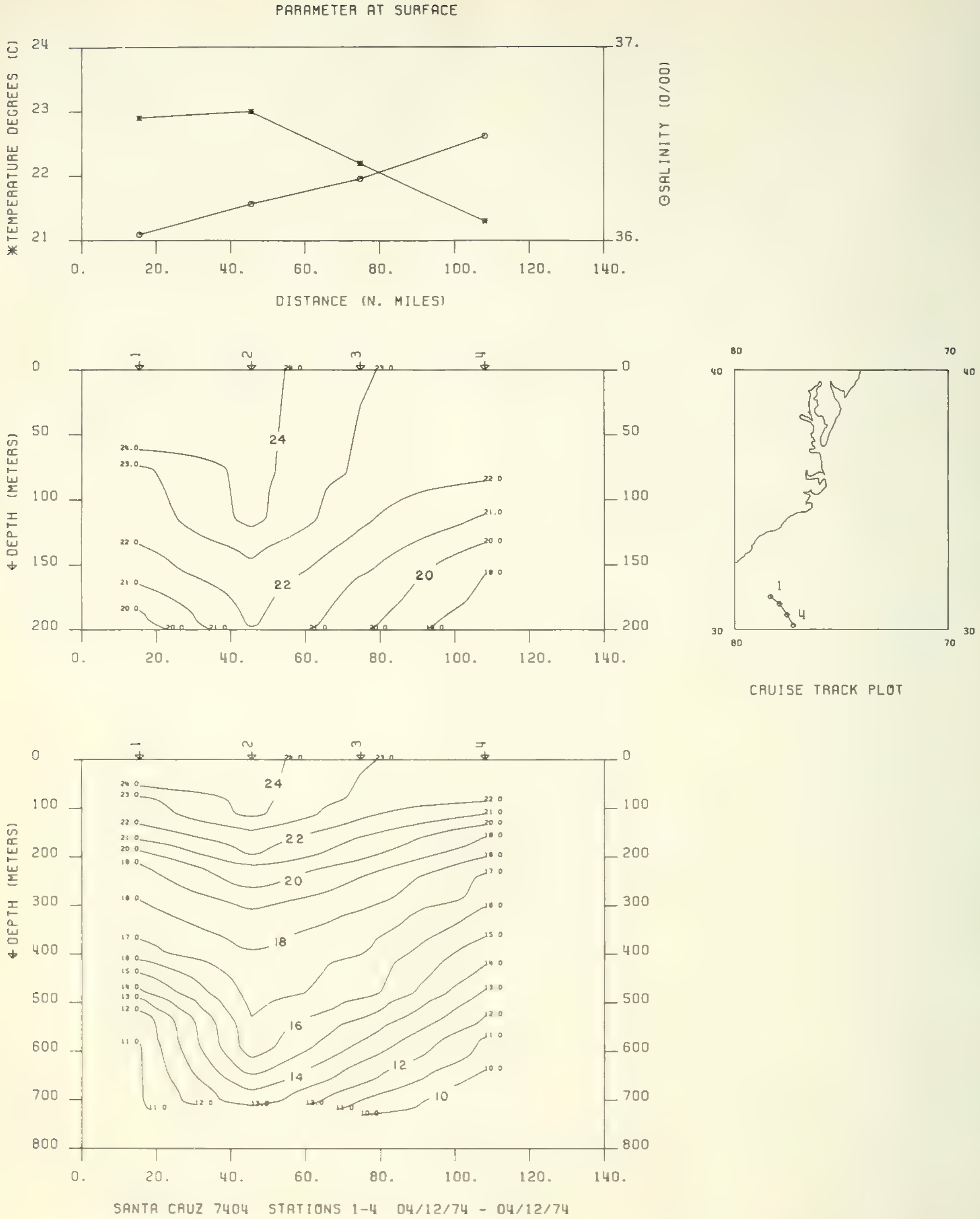
Appendix Figure 15.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 8 00 m. *Delta Norte*—1 December 1974.



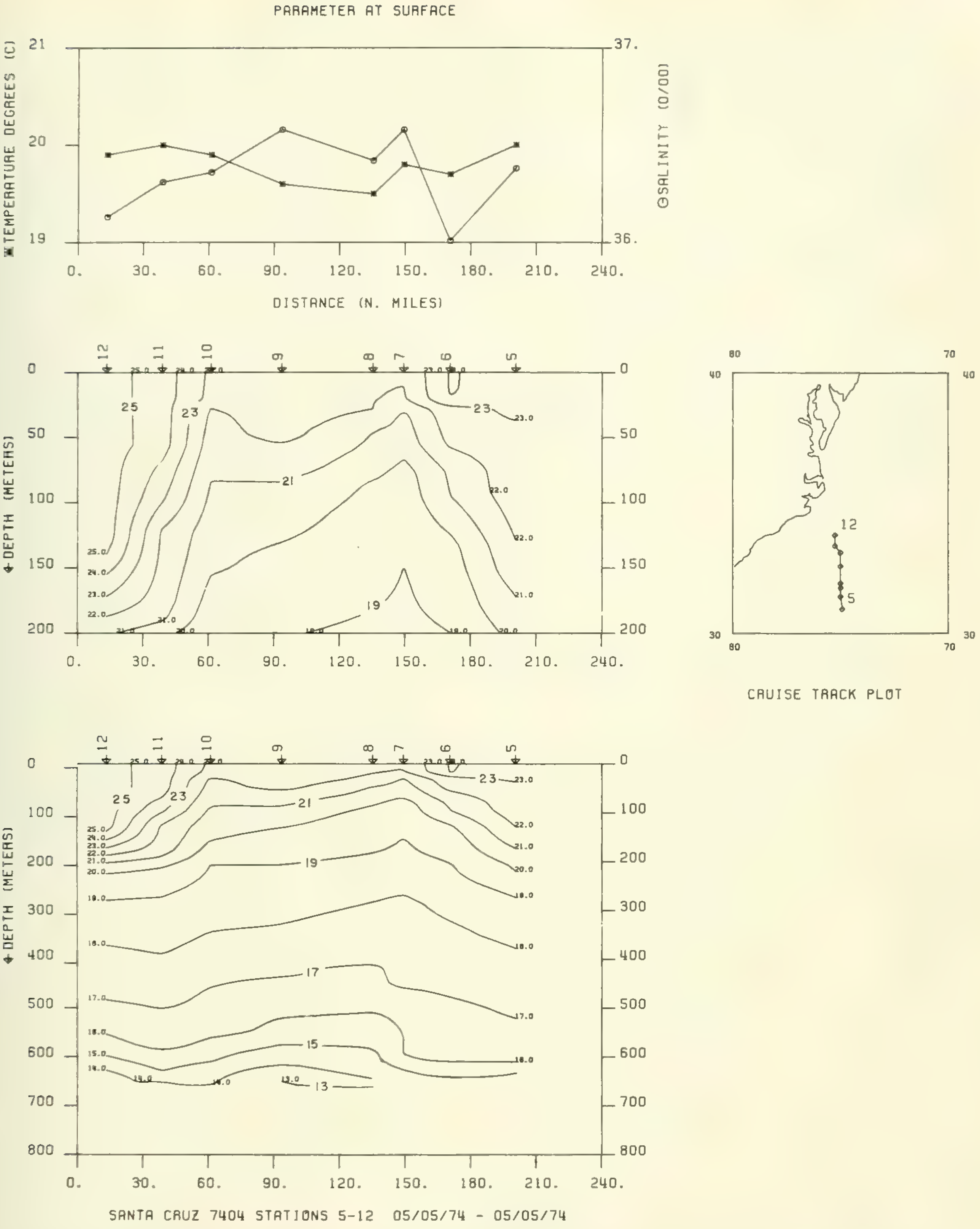
Appendix Figure 16.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Delta Norte*—1-2 December 1974.



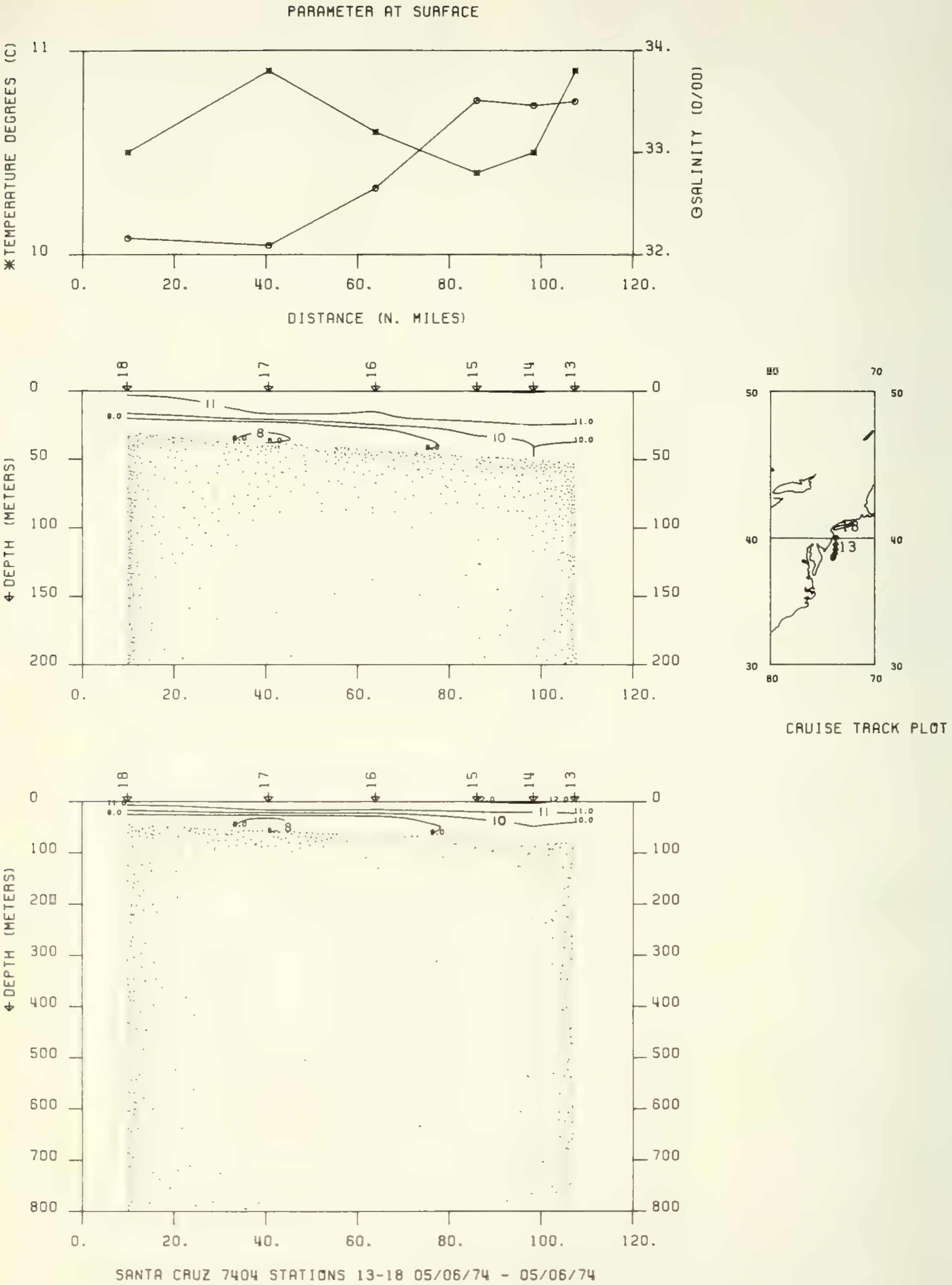
Appendix Figure 17.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—28 February 1974.



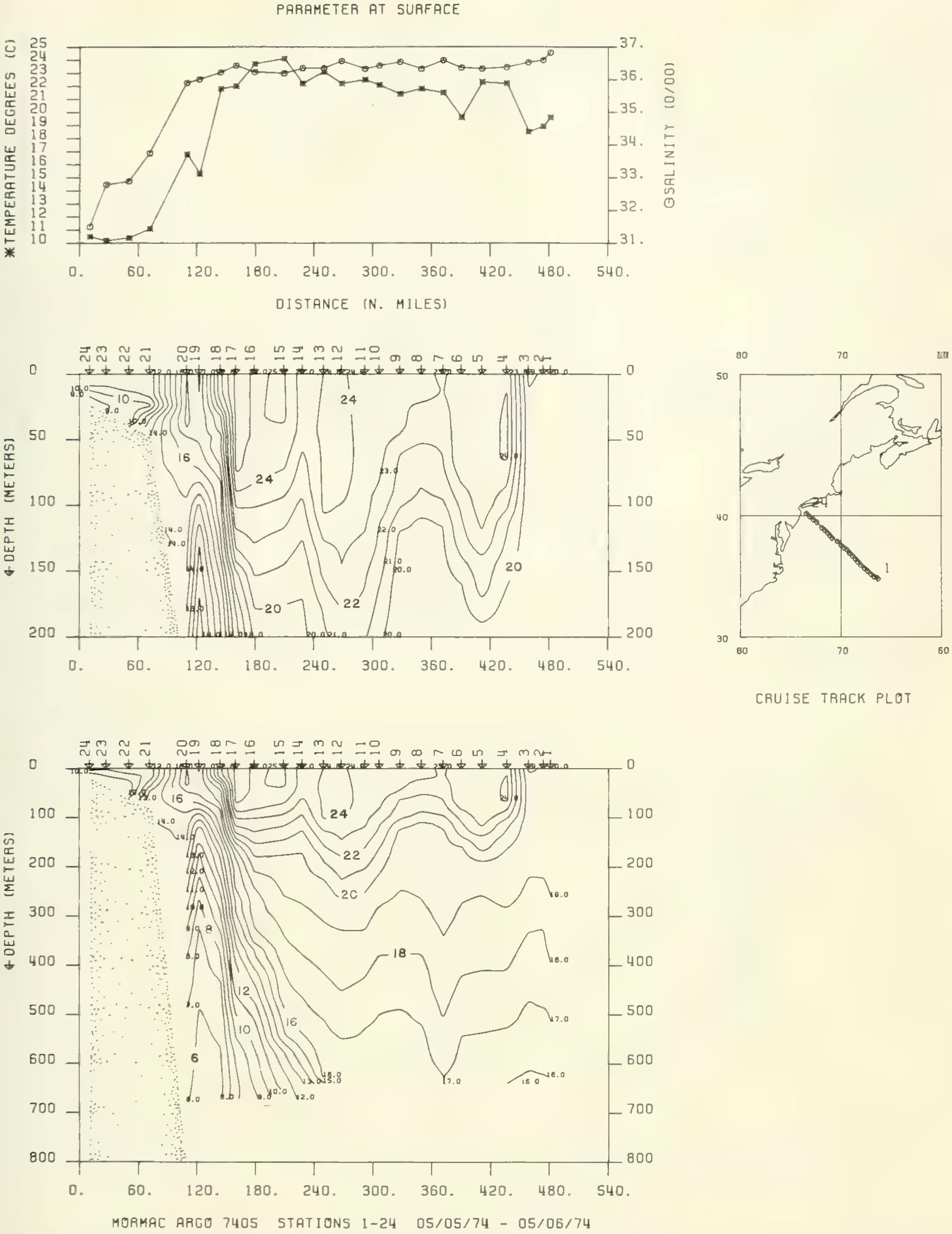
Appendix Figure 18.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—12 April 1974.



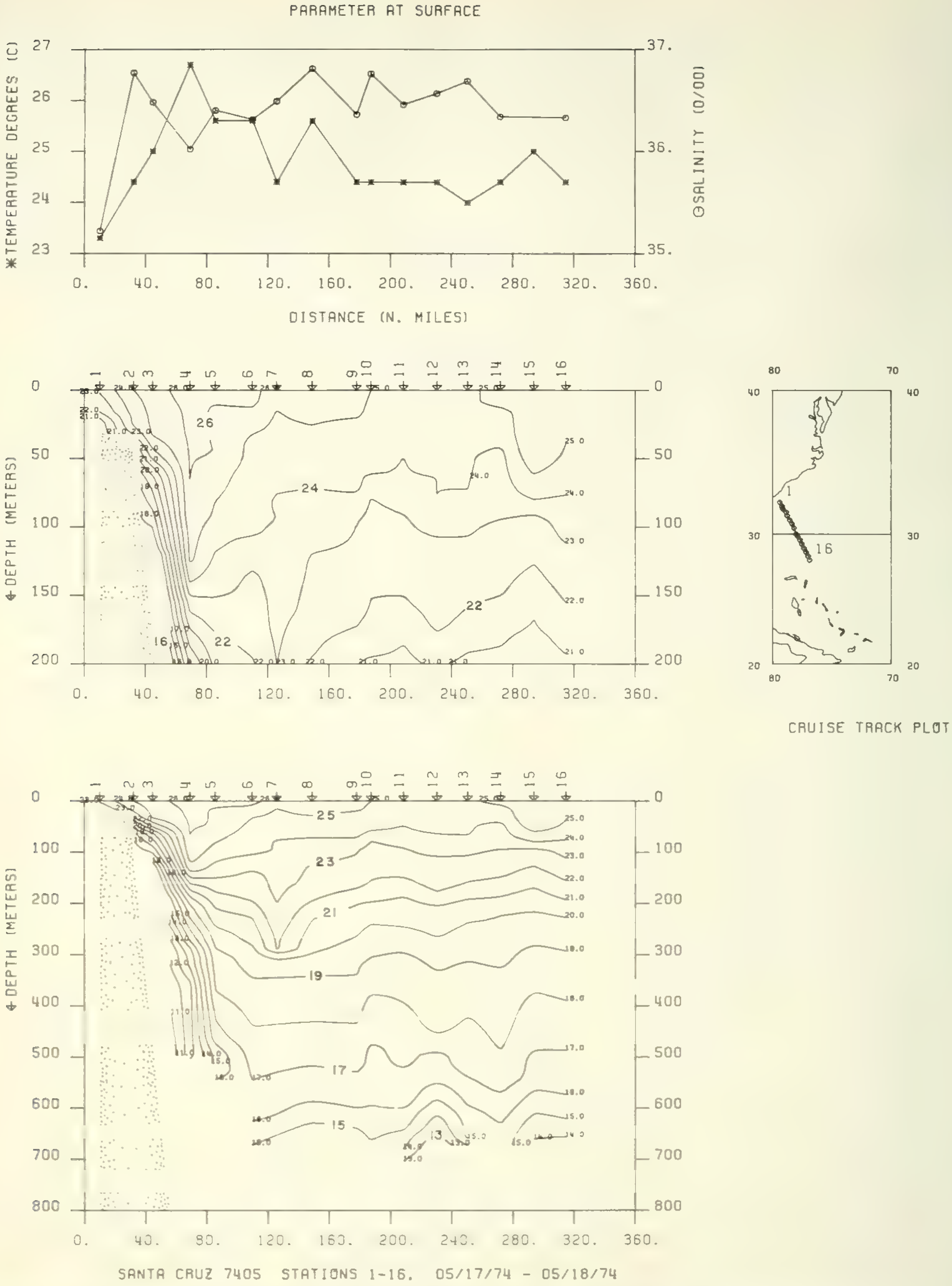
Appendix Figure 19.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—5 May 1974.



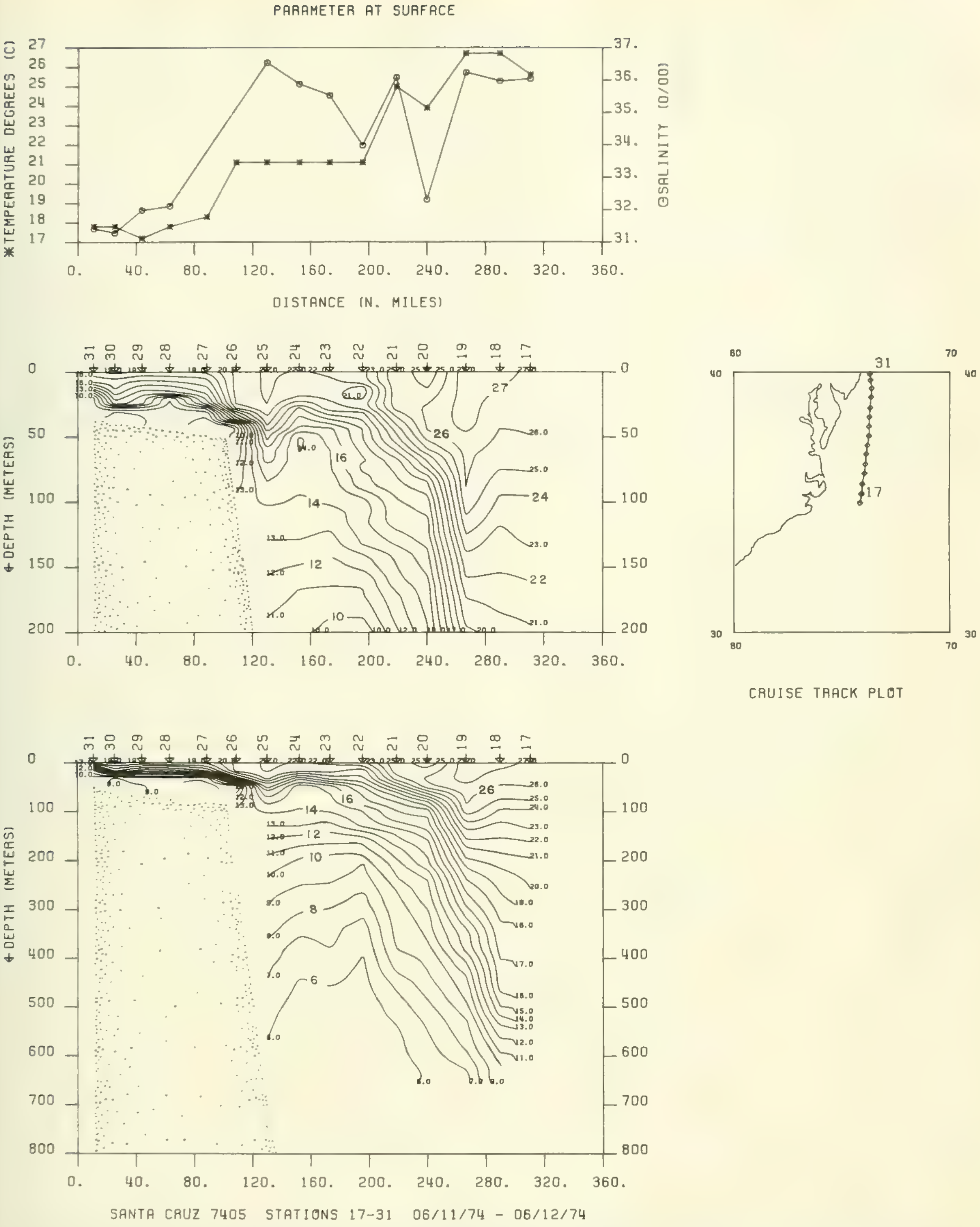
Appendix Figure 20.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—6 May 1974.



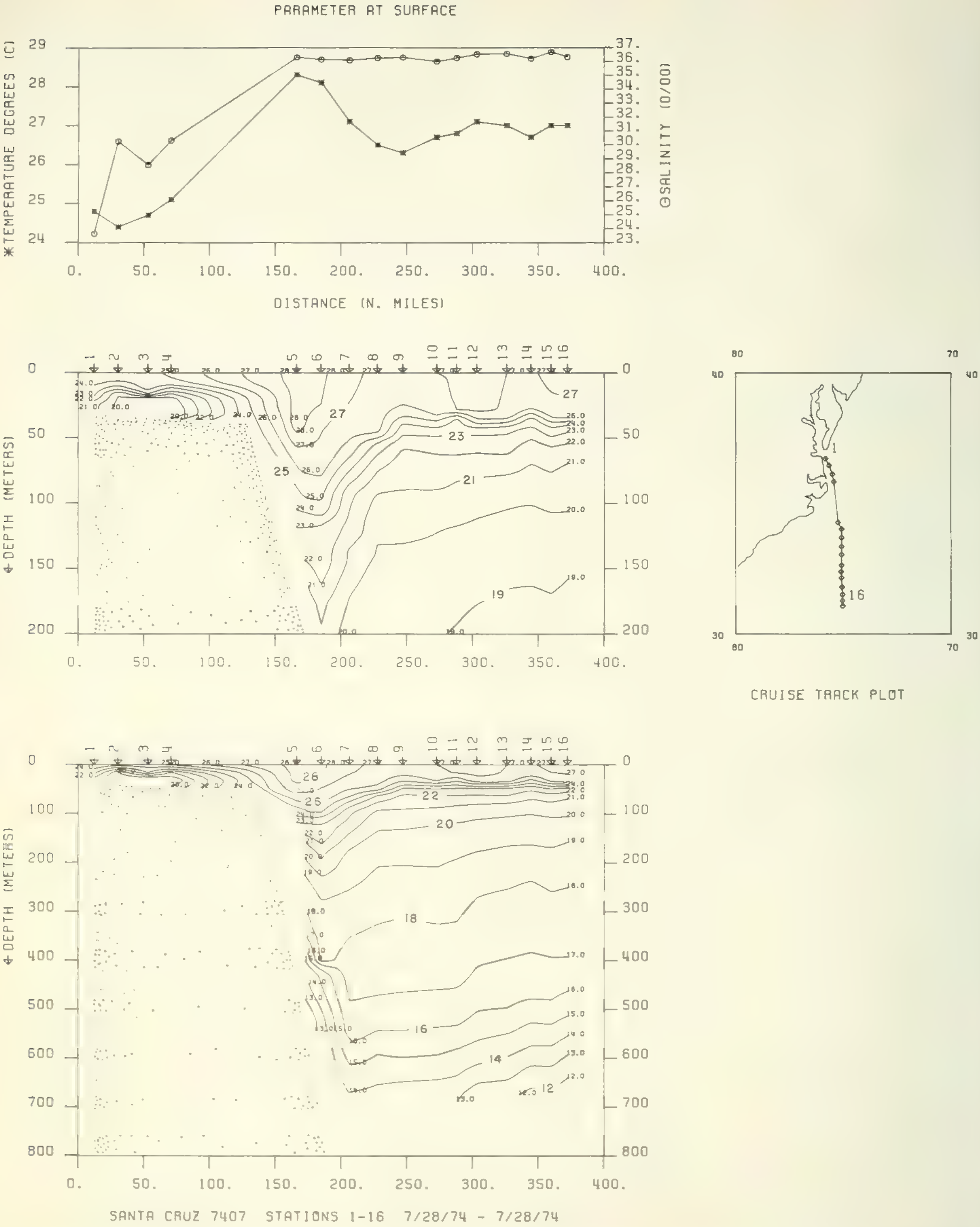
Appendix Figure 21.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mormac Argo*—5-6 May 1974.



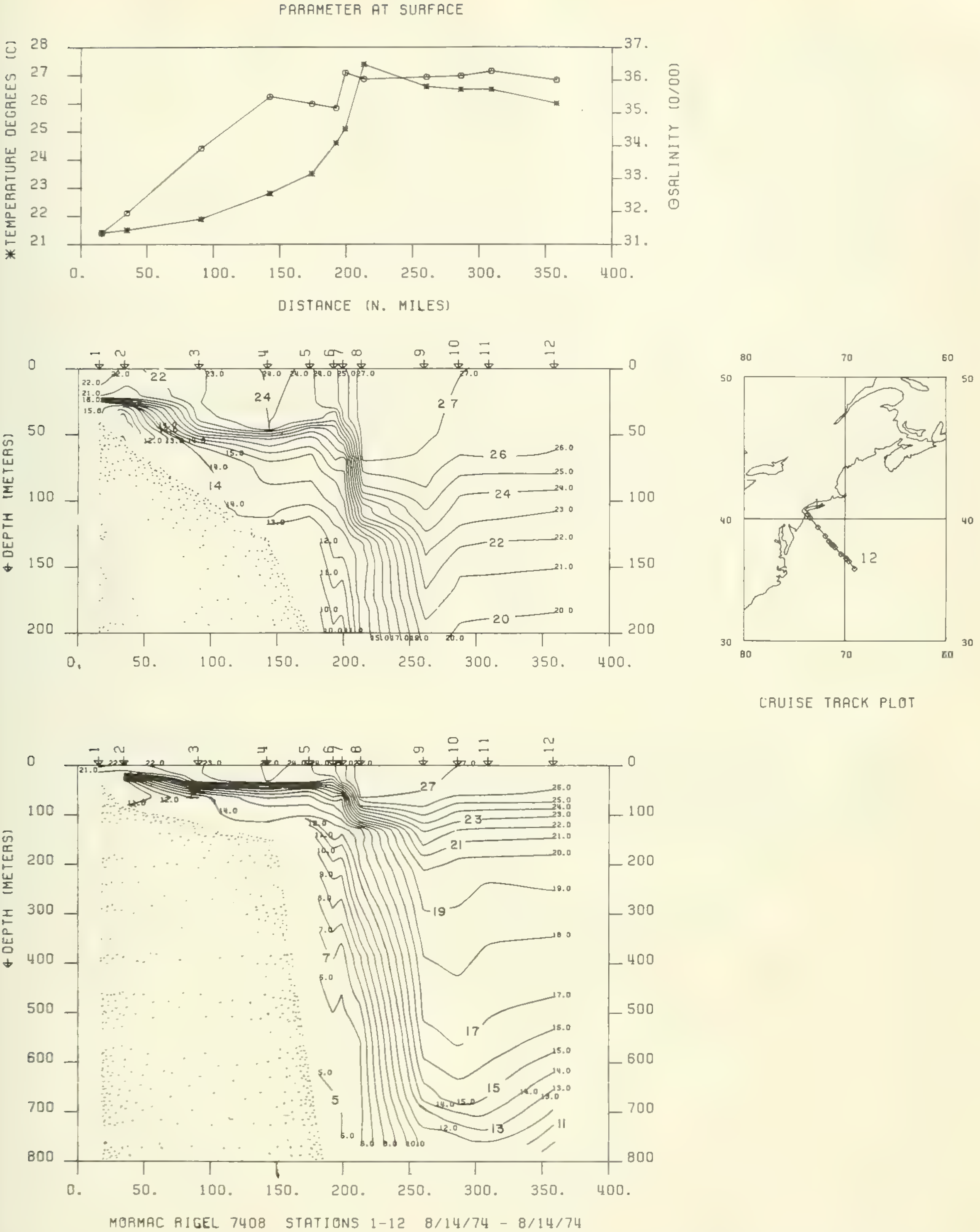
Appendix Figure 22.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—17-18 May 1974.



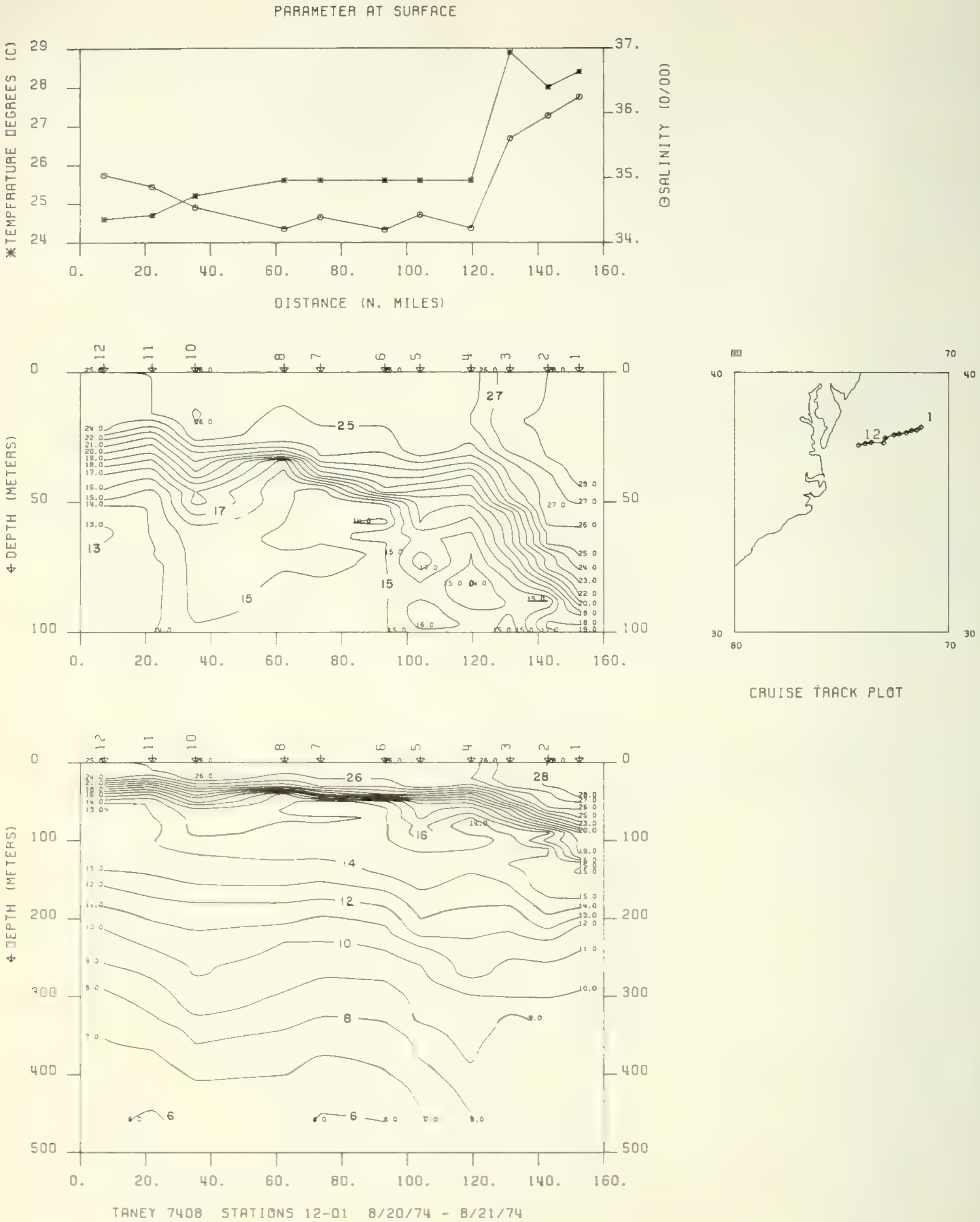
Appendix Figure 23.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—11-12 June 1974.



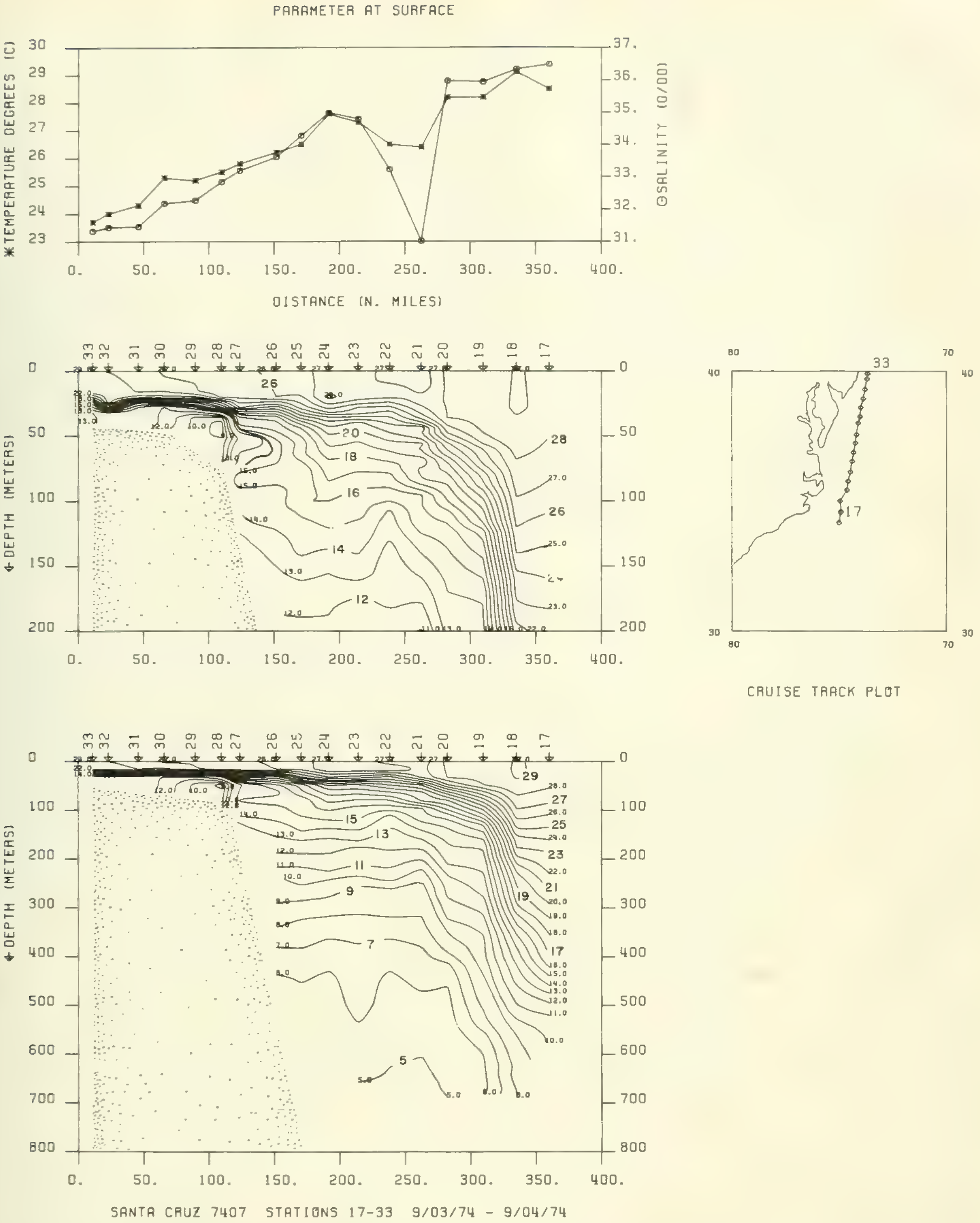
Appendix Figure 24.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—28 July 1974.



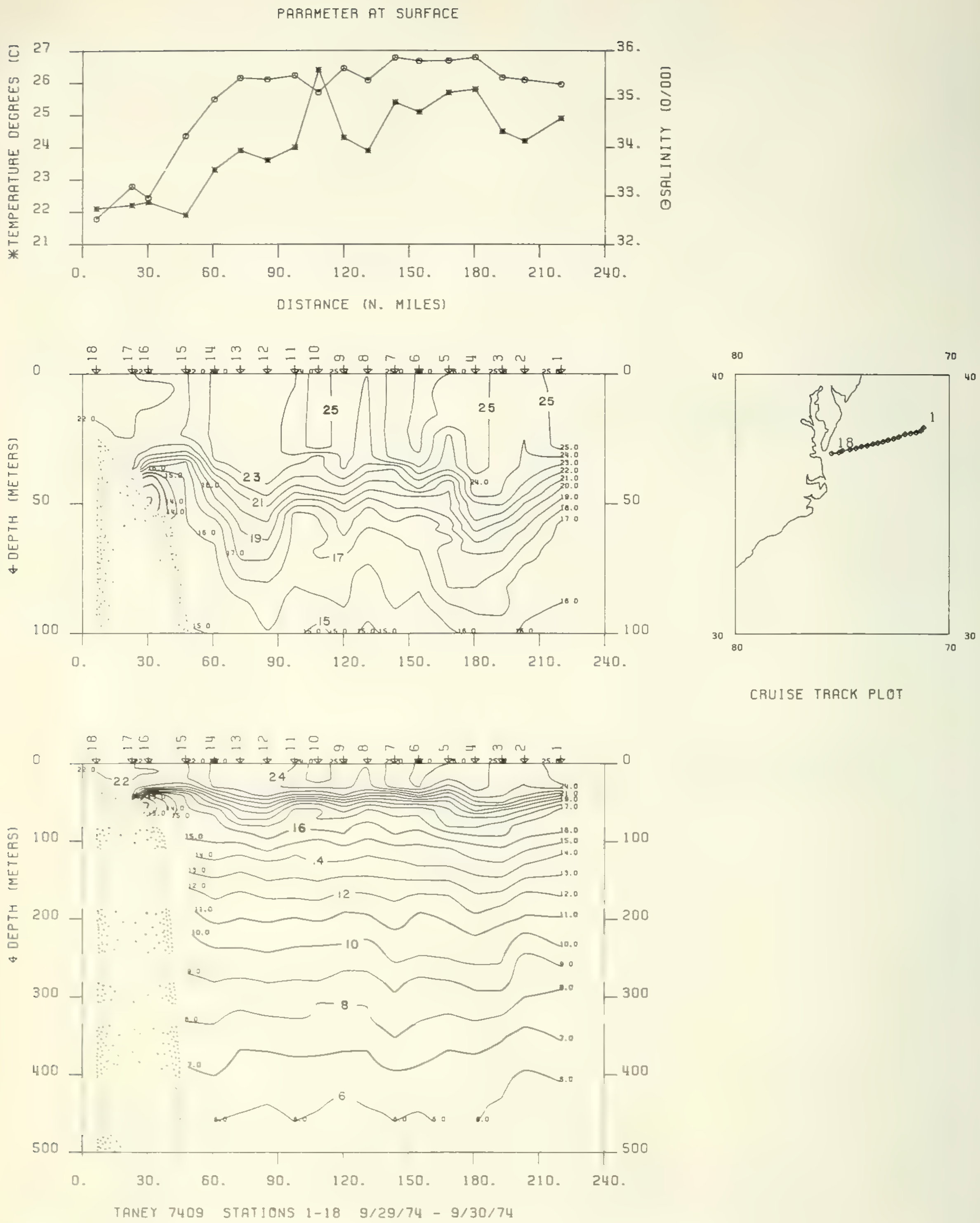
Appendix Figure 25.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mormac Rigel*—14 August 1974.



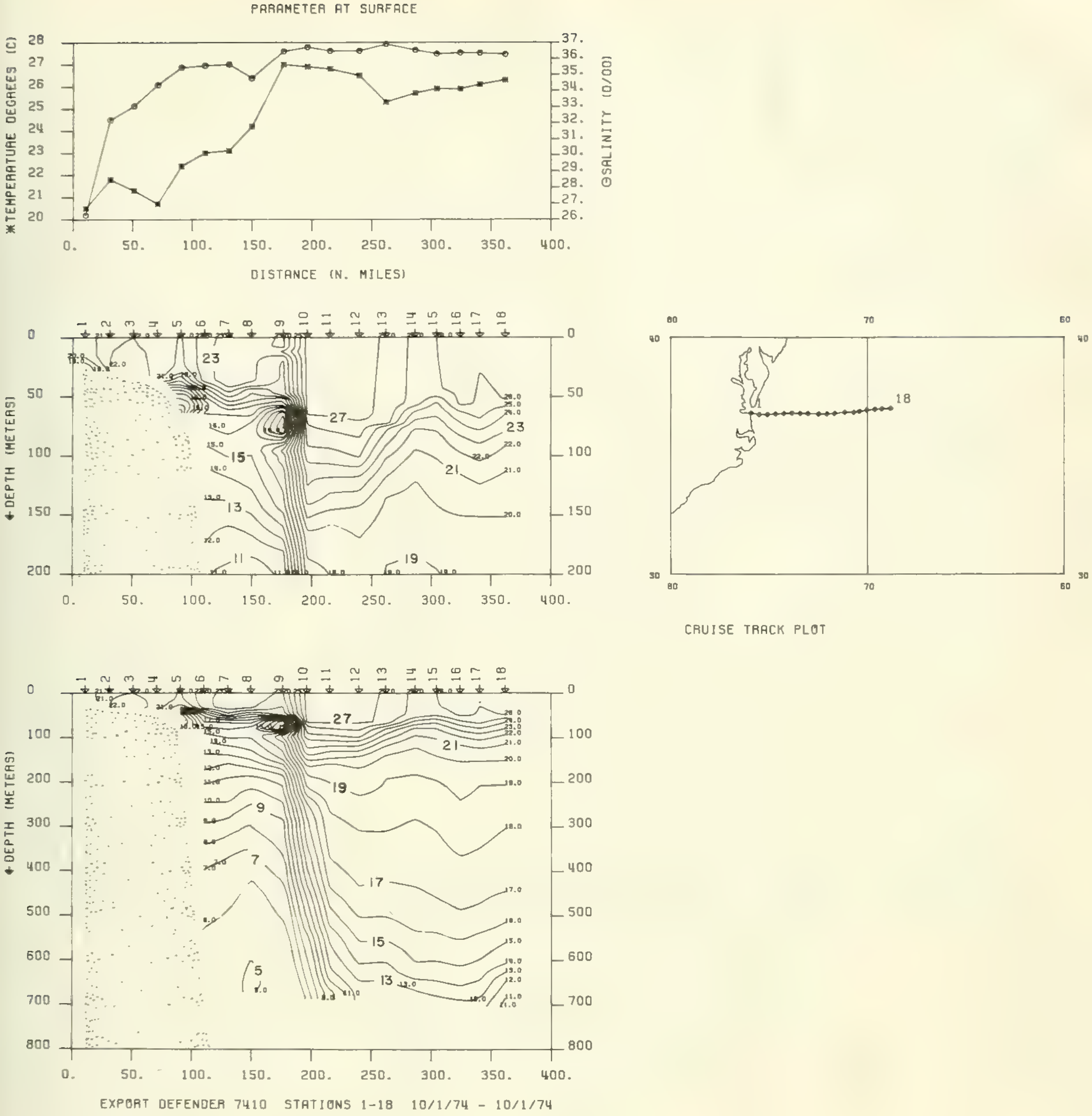
Appendix Figure 26.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. USCGC *Taney*—20-21 August 1974.



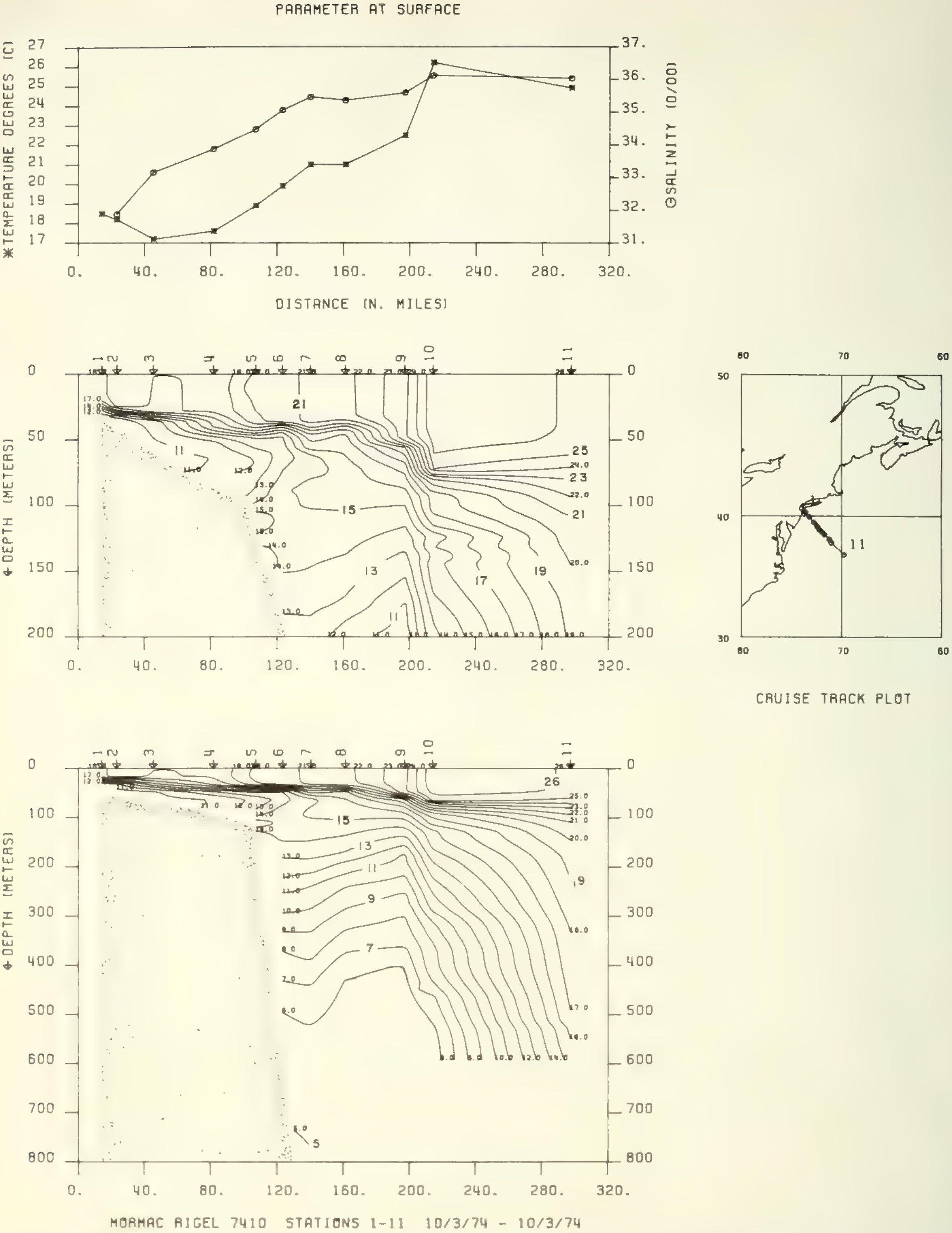
Appendix Figure 27.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—3-4 September 1974.



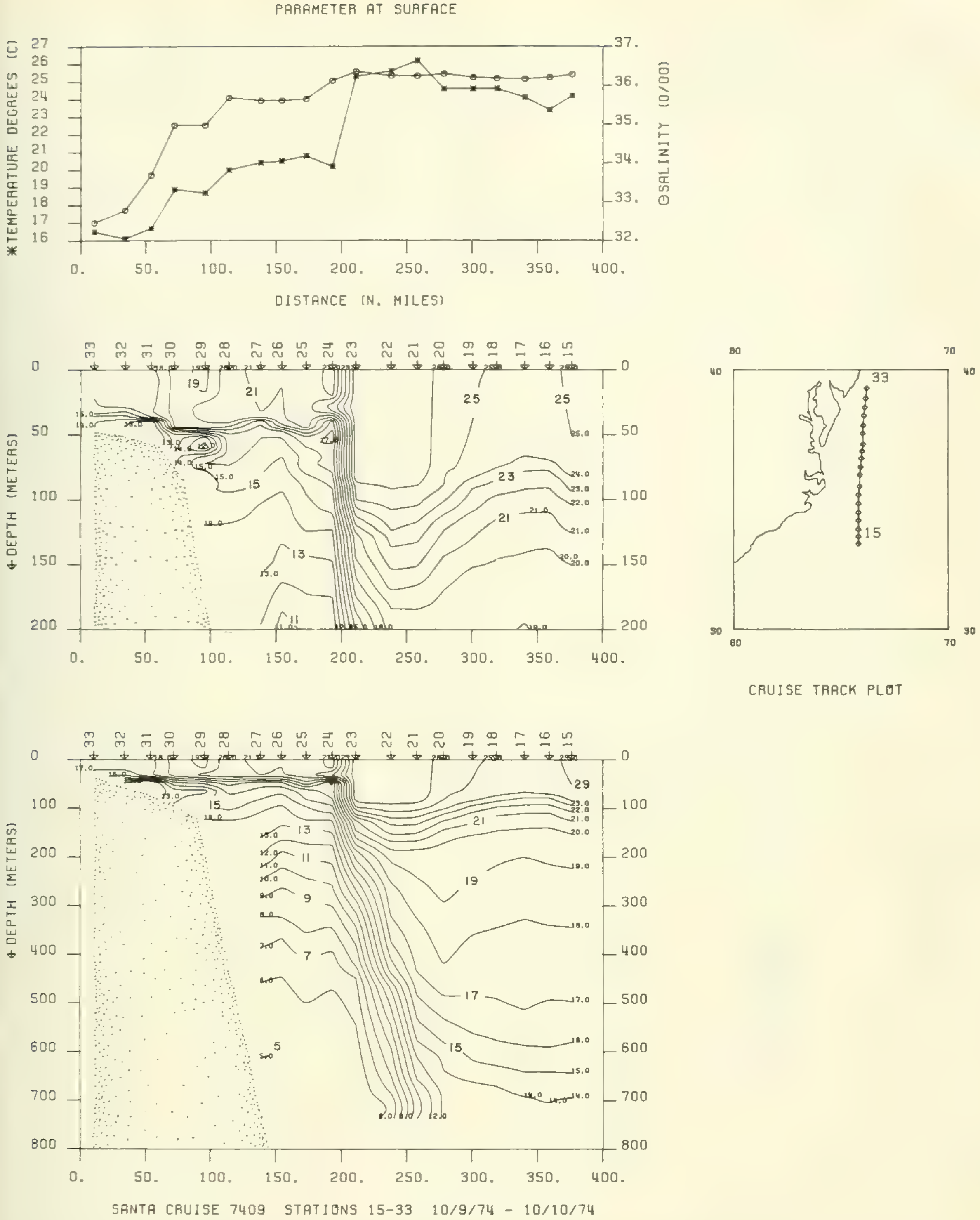
Appendix Figure 28.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/∘∘) and vertical distribution of temperature (°C) in the upper 200 and 800 m. USCGC *Taney*—29-30 September 1974.



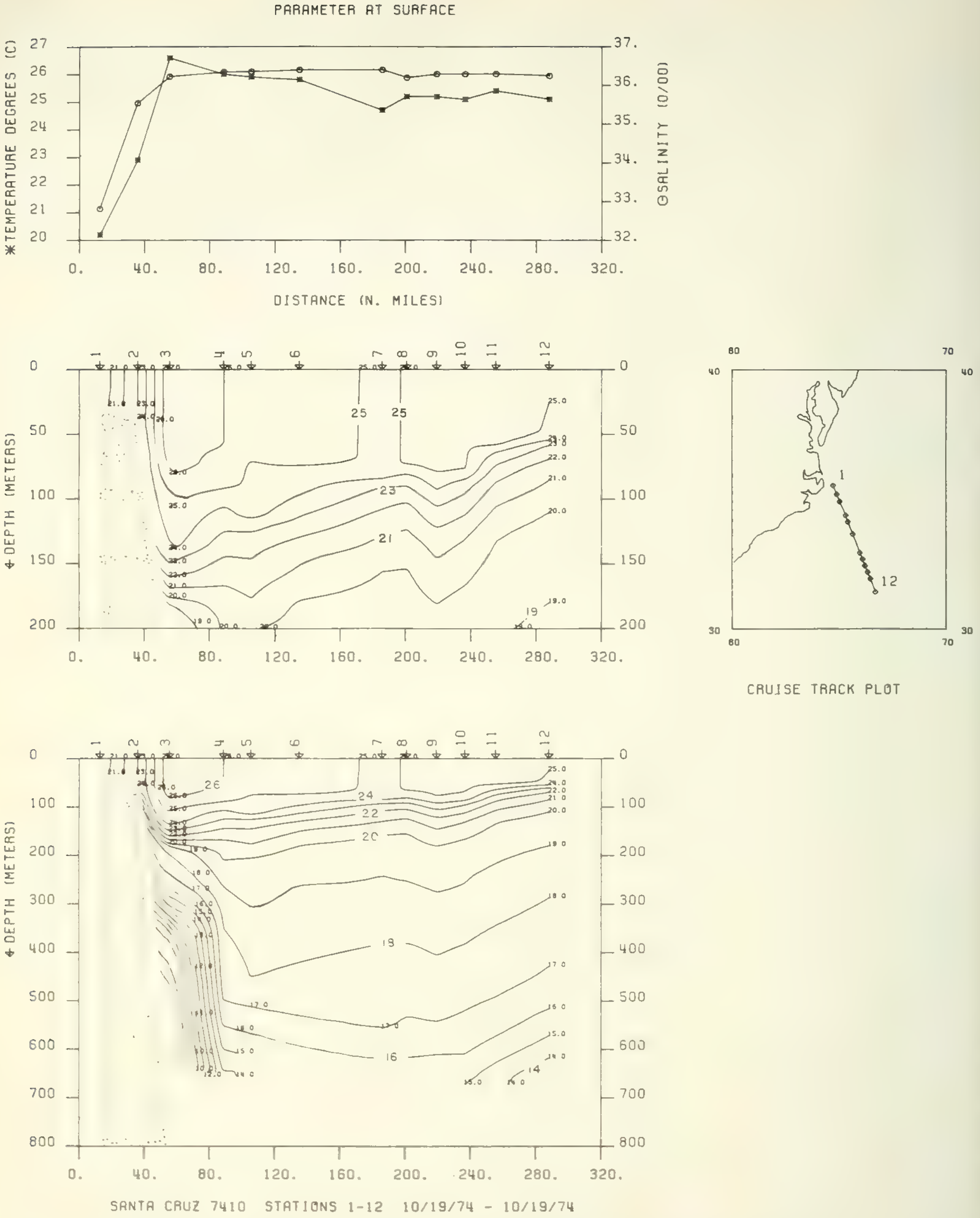
Appendix Figure 29.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Export Defender*—1 October 1974.



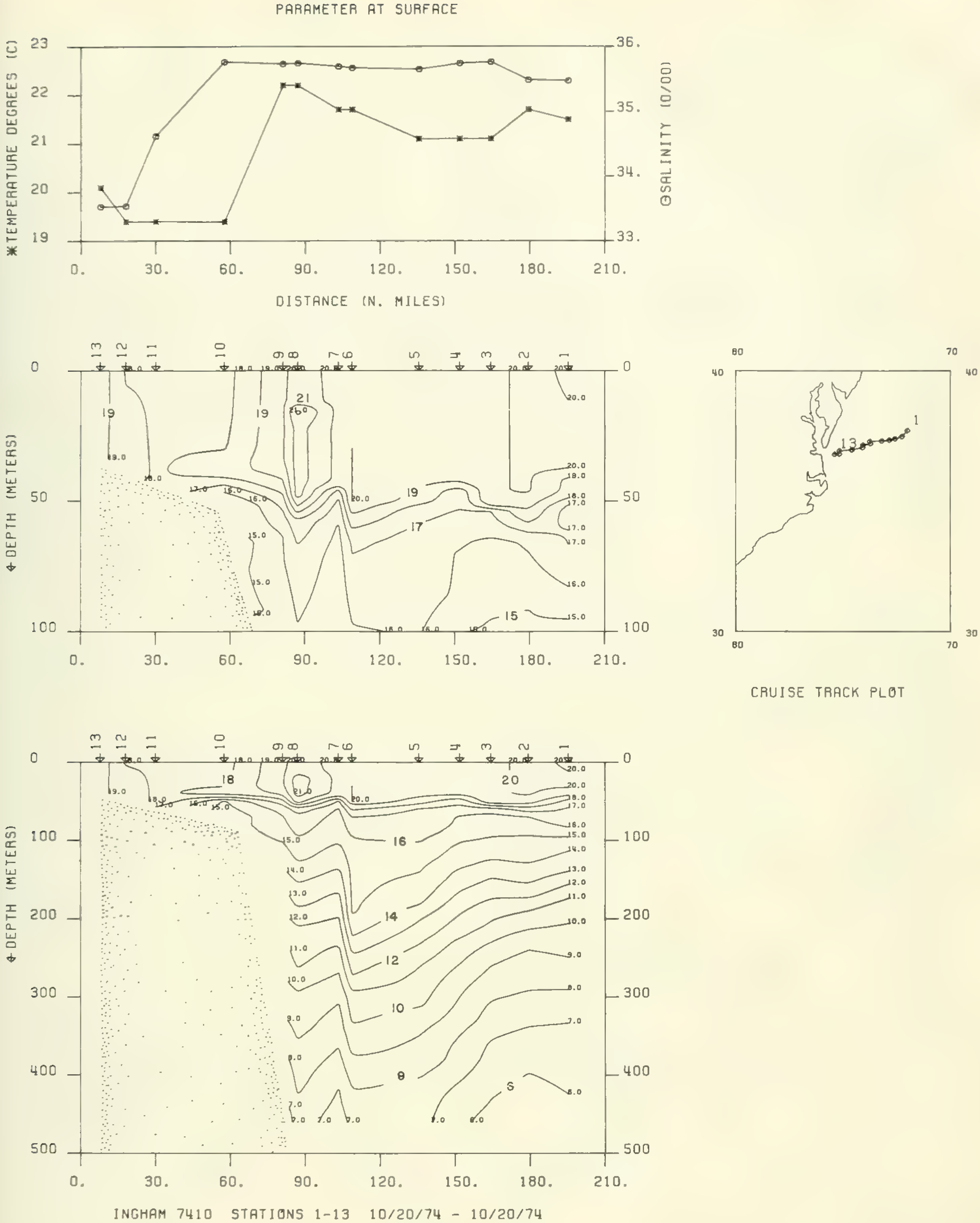
Appendix Figure 30.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Mormac Rigel*—3 October 1974.



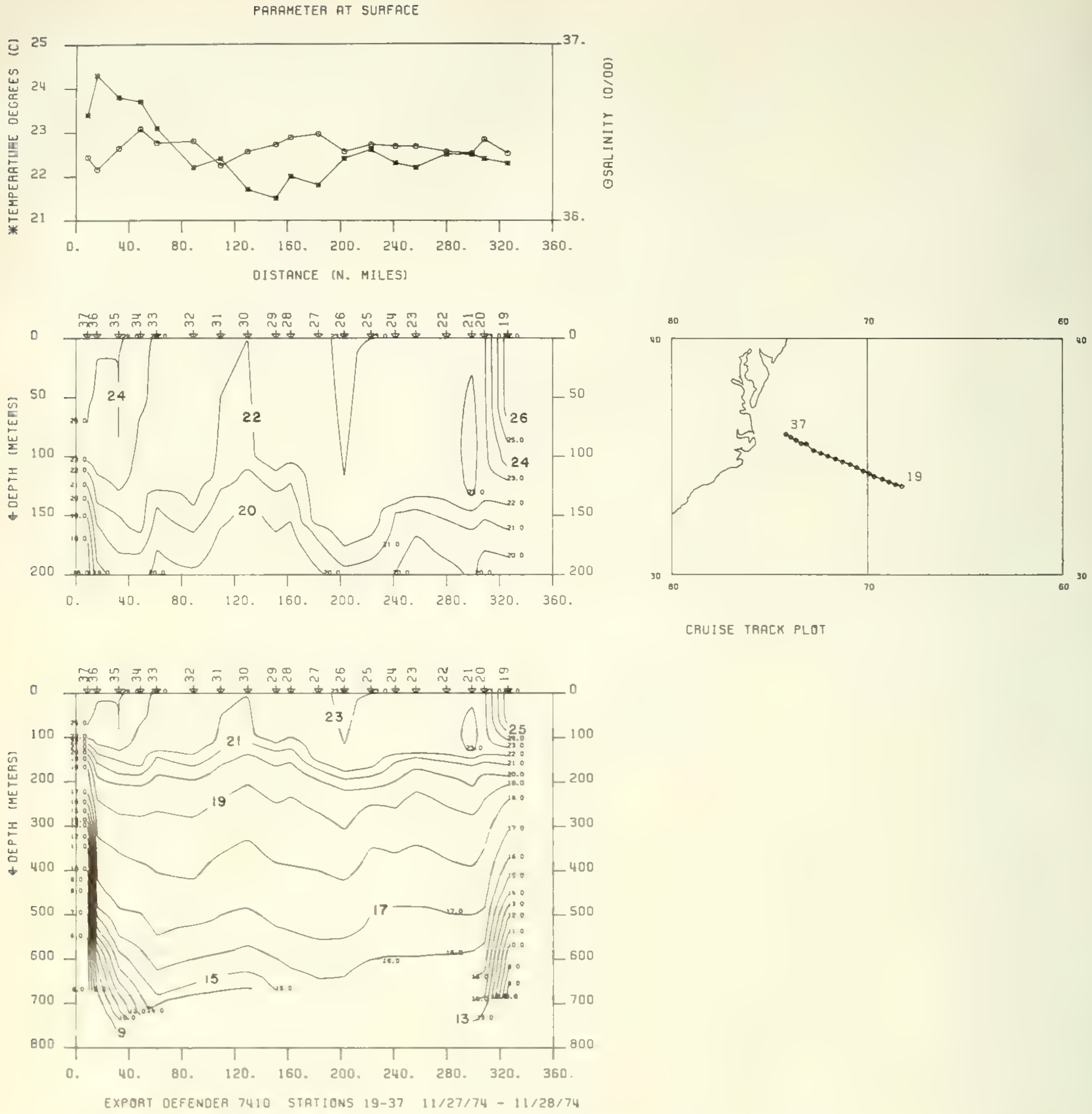
Appendix Figure 31.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—9-10 October 1974.



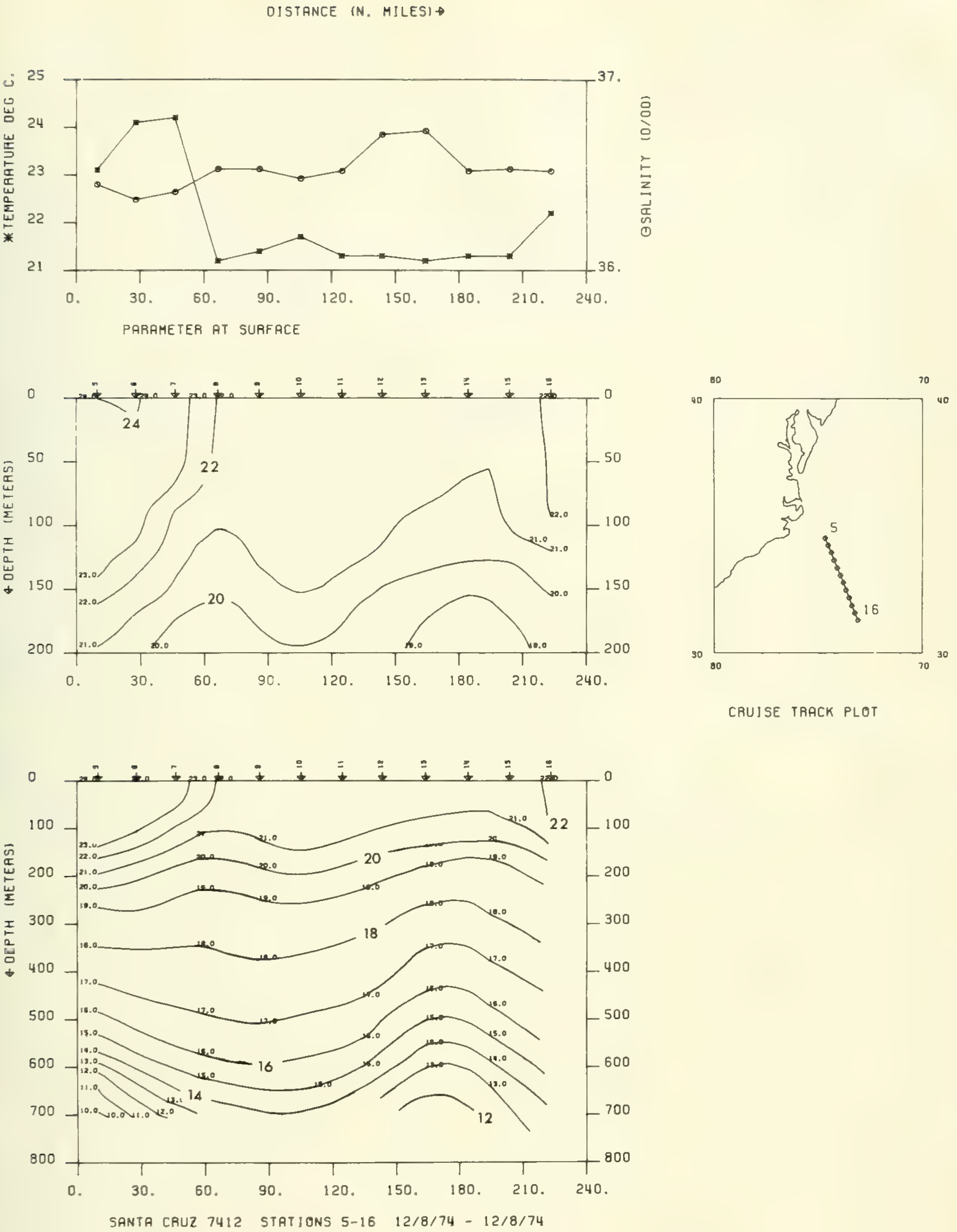
Appendix Figure 32.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—19 October 1974.



Appendix Figure 33.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/∘∘) and vertical distribution of temperature (°C) in the upper 200 and 800 m. USCGC *Ingham*—20 October 1974.



Appendix Figure 34.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Export Defender*—27-28 November 1974.



Appendix Figure 35.—Horizontal distribution of sea surface temperature (°C) and sea surface salinity (°/₀₀) and vertical distribution of temperature (°C) in the upper 200 and 800 m. *Santa Cruz*—7-8 December 1974.

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672. Seasonal occurrence of young Guld menhaden and other fishes in a northwestern Florida estuary. By Marlin E. Tagatz and E. Peter H. Wilkins. August 1973, iii + 14 p., 1 fig., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

673. Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. By Frank W. Steimle, Jr. and Richard B. Stone. December 1973, iii + 50 p., 2 figs., 5 app. tables.

674. Lake Erie bottom trawl explorations, 1962-66. By Edgar W. Bowman. January 1974, iv + 21 p., 9 figs., 1 table, 7 app. tables.

675. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 1. Report of the Symposium. March 1975, iii + 33 p.; Part 2. Review and contributed papers. July 1974, iv + 355 p. (38 papers); Part 3. Species synopses. June 1975, iii + 159 p. (8 papers). Richard S. Shomura and Francis Williams (editors). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

676. Price spreads and cost analyses for finfish and shellfish products at different marketing levels. By Erwin S. Penn. March 1974, vi + 74 p., 15 figs., 12 tables, 12 app. figs., 14 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

677. Abundance of benthic macroinvertebrates in natural and altered estuarine areas. By Gill Gilmore and Lee Trent. April 1974, iii + 13 p., 11 figs., 3 tables, 2 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

678. Distribution, abundance, and growth of juvenile sockeye salmon, *Oncorhynchus nerka*, and associated species in the Naknek River system, 1961-64. By Robert J. Ellis. September 1974, v + 53 p., 27 figs., 26 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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NOAA Technical Report NMFS SSRF-711

A List of the Marine Mammals of the World

JUN 1 5 1977

Dale W. Rice

April 1977

U.S. DEPARTMENT OF COMMERCE
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671. Coastal upwelling indices, west coast of North America, 1946-71. By Andrew Bakun. June 1973, iv + 103 p., 6 figs., 3 tables, 45 app. figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Continued on inside back cover

NOAA Technical Report NMFS SSRF-711

A List of the Marine Mammals of the World (Third Edition)

Dale W. Rice

April 1977

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
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[1] Numbers in parentheses indicate number of species in each family.

A List of the Marine Mammals of the World[1]

DALE W. RICE[2]

ABSTRACT

Listed are the 116 species of Recent marine mammals, including freshwater species of the predominantly marine groups. The number of species are: Order Carnivora, 36 (polar bear, sea otter, and 34 pinnipeds); Order Sirenia, 5; Order Mysticeti, 10; and Order Odontoceti, 65. The geographic distribution of each species is indicated.

INTRODUCTION

Listed here are the living and recently extinct marine mammals of the world: the sea otter, polar bear, pinnipeds, sirenians, and cetaceans. Living freshwater pinnipeds, sirenians, and cetaceans are included.

Attempts to classify marine mammals are difficult because they are poorly known. Some live on the high seas and others on remote oceanic islands or among polar ice fields. Some sirenians and smaller cetaceans live in tropical waters seldom visited by mammalogists. The carcasses of marine mammals are large, greasy, bloody, and often putrefied before they are brought to the attention of biologists. They are difficult and expensive to collect and to preserve for study. As a result, some kinds are represented in scientific collections by only a few skulls and their external appearance is poorly known. Thus, any list of the marine mammals, especially of the smaller cetaceans, can be regarded only as provisional.

The seals have usually been separated from the terrestrial carnivores as Order (or Suborder) Pinnipedia. It is now clear, however, that the pinnipeds had a common origin with the weasel, racoon, dog, and bear families, and together they constitute one of the two main subdivisions of living carnivores (Mitchell and Tedford 1973).

The cetaceans have usually been regarded as comprising a single order, but their origins are obscure, and it is questionable whether they are monophyletic. The Odontoceti (toothed whales) and the Mysticeti (baleen whales) have been separate since at least the late Eocene, and all authors have recognized them as valid taxa at either the subordinal or ordinal level. The differences between the two groups are as great as those between some of the universally recognized orders of mammals (Rice, in Anderson and Jones 1967). Therefore I follow Kleinenberg (1958) and some other authors in ranking them as separate orders.

In the Order Odontoceti, the species of the genera *Platanista, Sousa, Sotalia,* and *Tursiops* herein recognized as valid have been changed to conform to the "List of Smaller Cetaceans Recognized," agreed upon at the special meeting on smaller cetaceans held by the Scientific Committee of the International Whaling Commission (1975). The present list now agrees with the IWC Scientific Committee's list. It appears that the specific classification of the Odontoceti is approaching a consensus. Future studies may indicate that certain closely related allopatric forms now listed as separate species should be regarded as conspecific; such cases are noted in the text. Recent studies on some species of small cetaceans (e.g., *Stenella longirostris* and *S. attenuata*) have revealed considerable geographic variation. Most species of cetaceans are still too poorly known for subspecies to be defined, but I have listed the proposed subspecies that appear to be valid.

In the few cases where the nomenclature or classification in the present list differs from that in the working list compiled by the U.S. Marine Mammal Commission (1976), the reasons are explained in the text or in the references cited therein.

The following names are senior synonyms of names used in this list; according to Article 23b of the International Code for Zoological Nomenclature (International Trust for Zoological Nomenclature 1964), these names are nomina oblita and cannot replace the names herein employed:

Stenorhinchus E. Geoffroy St.-Hilaire and F. Cuvier, 1826 (= *Hydrurga* Gistel, 1848)
Susu Lesson, 1828 (= *Platanista* Wagler, 1830)
Nodus Wagler, 1830 (= *Mesoplodon* Gervais, 1850)
Tursiops nesarnack (Lacépède, 1804) [= *T. truncatus* (Montagu, 1821)]
Phoca vitulina stejnegeri Allen, 1902 (= *Phoca vitulina kurilensis* Inukai, 1942)
Hyperoodontidae Gray, 1846 (= Ziphiidae Gray, 1865).

Synonyms commonly used in recent literature are listed on page 12; see Scheffer (1958) for synonymy of pinnipeds and Hershkovitz (1966) for synonymy of cetaceans.

Vernacular names are included for most species. In selecting vernacular names, I have been guided, but not bound, by the principles adopted by the American Fisheries Society's Committee on Names of Fishes

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[1] A revision of two earlier lists under the same title (Scheffer and Rice 1963; Rice and Scheffer 1968).

[2] Marine Mammal Division Northwest Fisheries Center, National Marine Fisheries Service, NOAA, Seattle, WA 98115.

(Bailey et al. 1970) and the American Ornithologists' Union's Committee on Classification and Nomenclature (1973). Many small cetaceans lack distinctive vernacular names; hence some names listed here are "book" names. I am not attempting to "standardize" vernacular names—the time is not ripe for that. I hope that field workers will record or invent more appropriate names where needed.

The report deals only with the Recent marine mammals. Readers interested in fossil forms are referred to the following publications: Winge (1921); Miller (1923); Kellogg (1928, 1936); Slijper (1936); Simpson (1945); Piveteau (1958, 1961); Reinhart (1959); Matthes (1962); King (1964); and Romer (1966).

Order CARNIVORA

The living carnivores comprise two superfamilies—Feloidea (mongooses, cats, hyenas, etc.) and Canoidea (dogs, bears, raccoons, weasels, seals, etc.) (Mitchell and Tedford 1973). Only the latter superfamily includes marine species.

Family URSIDAE

There are five living genera of bears and giant pandas (Hendey 1972), but only one contains a marine species.

Genus URSUS Linnaeus, 1758

Only one of the four species of this genus is marine.

Ursus maritimus Phipps, 1774 (polar bear).
Ice-covered regions of Arctic Ocean and contiguous seas, and adjacent coasts and islands.

Family ODOBENIDAE

Mitchell (1975) regarded the walruses as a subfamily of the Otariidae, whereas Repenning (1975) maintained them as a separate family. Pending a consensus, I follow most previous authors in listing them as a separate family.

Genus ODOBENUS Brisson, 1762

Odobenus rosmarus (Linnaeus, 1758) (walrus).
Shallow waters near ice in the Arctic Ocean and adjacent seas. Three subspecies are currently recognized: *O. r. rosmarus* in the Atlantic-Arctic; *O. r. divergens* (Illiger, 1815), in the Pacific-Arctic; and *O. r. laptevi* Chapskii, 1940, in the Laptev Sea. The Atlantic subspecies contains two breeding groups, one from the Kara Sea to eastern Greenland and another from western Greenland and eastern Canada. The latter population may be subspecifically distinct. There are late Pleistocene to prehistoric records as far south as California, Michigan, North Carolina, and France (Repenning, pers. commun.).

Family OTARIIDAE

Genus PHOCARCTOS Peters, 1866

Phocarctos hookeri (Gray, 1844) (Auckland sea lion; New Zealand sea lion).
Subantarctic islands south of New Zealand; breeds regularly only at Carnley Harbor and Enderby Island in the Auckland Islands, rarely at Campbell Island. Hauls out on Snares Islands, Macquarie Island, and South Island, N.Z. Occurred on North Island, N.Z., less than 1,000 yr ago. For discussion of the relationships of *Phocarctos*, *Neophoca*, and *Zalophus* see King (1960).

Genus OTARIA Péron, 1816

Otaria flavescens (Shaw, 1800) (South American sea lion).
Coastal waters from Recife das Tôrres, Brazil, and Zorritos, Peru, southward to Strait of Magellan and Falkland Islands. Some authors have used the specific name *byronia* de Blainville, 1820, but P. Hershkovitz pointed out (pers. commun.) that "the type of *flavescens* was a tangible specimen preserved in the old Leverian museum. It was adequately described and figured, is perfectly identifiable, and has a valid type locality. Its name has priority, usage and currency."

Genus ZALOPHUS Gill, 1866

Zalophus californianus (Lesson, 1828) (black sea lion; California, Japanese, and Galapagos sea lions).
One subspecies, *Z. c. californianus,* breeds from San Miguel Island, Calif., south to Punta Entrada, Baja California, and on islands in the upper Gulf of California, ranging at sea north to Vancouver Island, south to Cabo San Lucas and Mazatlán. A second subspecies of unconfirmed validity, *Z. c. japonicus* (Peters, 1866), was known from the Sea of Japan but was probably exterminated in the 1950's (International Union for Conservation of Nature and Natural Resources 1972; Nichiwaki 1973). A third subspecies, *Z. c. wollebaeki* Sivertsen, 1953, breeds on the Galápagos Islands.

Genus NEOPHOCA Gray, 1866

Neophoca cinerea (Péron, 1816) (Australian sea lion).
Coastal waters from Kangaroo Island, South Australia, to Houtman Rocks, Western Australia. There is a late Pleistocene record from Melbourne, Victoria.

Genus EUMETOPIAS Gill, 1866

Eumetopias jubatus (Schreber, 1776) (northern sea lion).

Breeds along west coast of North America from San Miguel Island, Calif., northwest to Prince William Sound and the Alaska Peninsula, throughout the Aleutian and Pribilof islands, along the east coast of Kamchatka, throughout the Kuril Islands, and on islands in the Okhotsk Sea. Some move north into the Bering Sea in summer, as far as St. Lawrence Island. Sometimes hauls out on ice. The spelling of *jubatus* follows a rule in International Trust for Zoological Nomenclature (1964:31): "a noun of variable gender . . . is to be treated as masculine . . . ."

Genus CALLORHINUS Gray, 1859

Calorhinus ursinus (Linnaeus, 1758) (northern fur seal).

Breeds on Ostrov Tyuleniy (Robben Island) in the Okhotsk Sea, some of the Kuril Islands, the Pribilof and Commander islands in the Bering Sea, and San Miguel Island off southern California. Formerly bred on Ostrov Iony in the Okhotsk Sea 120 miles north of Sakhalin (Stejneger 1898), and possibly on Buldir Island in the Aleutians (Murie 1959) and the Farallon Islands off central California (Repenning et al. 1971). Bones, including those of young pups, from San Miguel Island, the Monterey area, and Año Nuevo Point, Calif., and from Bella Bella, British Columbia, suggest that it formerly bred all along the west coast from San Miguel Island to Alaska (Repenning, pers. commun.).

Genus ARCTOCEPHALUS E. Geoffroy Saint-Hilaire and F. Cuvier, 1826

The breeding ranges of the species of *Arctocephalus* are strictly allopatric; further studies on the relationships of these seals are much needed. The present classification follows Repenning et al. (1971).

Arctocephalus pusillus (Schreber, 1776) (Giant fur seal; Victorian, or Tasmanian, and South African, or Cape, fur seals).

There are two widely separated subspecies. *Arctocephalus p. pusillus* breeds in temperate coastal waters from Cape Cross, South West Africa, to Algoa Bay, South Africa; ranges north to Angola. *Arctocephalus p. doriferus* Wood Jones, 1925, breeds along the coast of southeastern Australia from Lady Julia Percy Island east to the Skerries, Victoria, including coasts of Tasmania and islands in Bass Strait; ranges east to Port Stephens, N.S.W.

Arctocephalus gazella (Peters, 1875) (Antarctic fur seal).

Islands south of the Antarctic Convergence; South Shetlands, South Orkneys, South Sandwich, South Georgia, Bouvet, Kerguelén (not breeding), Heard, and McDonald.

Arctocephalus forsteri (Lesson, 1828) (Antipodean fur seal; Western Australian and New Zealand fur seals).

Breeds around South Island, N.Z., on nearby subantarctic islands (Chatham, Bounty, Antipodes, Auckland, Campbell, Macquarie, Snares, Stewart, and Solander), and along coast of southwestern Australia from Eclipse Island, Western Australia, to Kangaroo Island, South Australia.

Arctocephalus tropicalis (Gray, 1872) (subantarctic fur seal).

Subantarctic islands of Atlantic Ocean and Indian Ocean, north of the Antarctic Convergence (Tristan da Cunha, Gough, Marion, Prince Edward, Crozet (not breeding), Amsterdam, and St. Paul). Rarely wanders to South Africa, New Zealand, and Macquarie Island.

Arctocephalus australis (Zimmerman, 1783) (South American fur seal).

Falkland Islands; coasts of South America from Tierra del Fuego north to Rio de Janeiro, Brazil, and Lima, Peru. The proposed subspecific separation of the Falkland Islands and mainland populations is not justifiable (Vaz Ferreira 1976).

Arctocephalus galopagoensis Heller, 1904 (Galapagos fur seal).

Confined to the Galápagos Islands.

Arctocephalus philippii (Peters, 1866) (Juan Fernandez fur seal).

Now known to breed only on the Islas Juan Fernandez, Chile. Probably bred formerly on Isla San Felix and Isla San Ambrosio, Chile.

Arctocephalus townsendi Merriam, 1897 (Guadalupe fur seal).

Now known to breed only on Isla Guadalupe, Baja California. Occasionally seen on other islands off southern California and Baja California (San Miguel, San Nicholas, and Cedros), where it may have bred formerly. An old sealer's report from Isla Socorro (Morrell 1832) and bones from an Indian midden on Monterey Bay (Repenning, pers. commun.) suggest that it originally ranged more widely.

Family MUSTELIDAE

This family includes the weasels, badgers, otters, and their allies. Only the otters (subfamily Lutrinae) include marine species and only the sea otter is usually regarded as marine, although several species of river otters of the genus *Lutra*—especially the chungungo, *L. felina* (Molina, 1782), of Chile and Peru—feed extensively in salt water.

Genus ENHYDRA Fleming, 1822

Enhydra lutris (Linnaeus, 1758) (sea otter).
Formerly ranged from Morro Hermoso, Baja California, north along the coast to Prince William Sound and the south shore of the Alaska Peninsula, throughout the Aleutian, Pribilof, and Commander islands, along the southeast coast of Kamchatka, and through the Kuril Islands to northern Hokkaido. Three subspecies are recognizable (Roest 1973; Davis and Lidicker 1975): *E. l. nereis* (Merriam, 1904) from Mexico to Prince William Sound, Alaska; *E. l. lutris* from the Aleutian and Commander islands; and *E. l. gracilis* (Bechstein, 1799) in Kamchatka and the Kuril Islands. (The Aleutian race has been introduced into Oregon, Washington, British Columbia, and southeastern Alaska, where the indigenous stock was extirpated.)

Family PHOCIDAE

Genus PHOCA Linnaeus, 1758

Scheffer (1958) raised *Pusa* (including *hispida, caspica,* and *sibirica*), *Pagophilus* (*groenlandicus*), and *Histriophoca* (*fasciata*) to generic rank, but Burns and Fay (1970) have shown that they deserve only subgeneric rank.

Phoca vitulina Linnaeus, 1758 (harbor seal).
Shores of North America and Eurasia from Hokkaido, Baja California, North Carolina, and Spain north to the edge of arctic ice. Gives birth on land in May-August; the pup sheds its white coat in utero. The Atlantic subspecies, *P. v. vitulina*, is distinguishable from the Pacific subspecies by skull characters. Western North Atlantic seals are sometimes listed as a separate subspecies from those on the eastern side, but Doutt (1942) could find no differences between seals of the eastern and western Atlantic. *Phoca v. mellonae* Doutt, 1942, is said to be confined to the Seal Lakes complex of the Ungava Peninsula, though Mansfield (1967) doubted the validity of the subspecies. *Phoca v. richardii* (Gray, 1864) occurs in the eastern North Pacific west to the Aleutians, where it intergrades with *P. v. kurilensis* Inukai, 1942, of the western North Pacific (Shaughnessy 1974).

Phoca largha Pallas, 1811 (spotted seal; larga seal).
Chukchi, western Beaufort, northern Bering, Okhotsk, and Japan seas, southwest to the Shantung Peninsula, China. Reproductively isolated from *P. vitulina*, with which it is sympatric in the Kuril Islands and along the north shore of the Alaska Peninsula (Belkin 1964; McLaren 1966; Burns 1970). Gives birth on ice in late winter or spring and the pup retains its white coat for a week or more after birth.

Phoca hispida Schreber, 1775 (ringed seal).
Throughout the Arctic Ocean and adjacent seas, chiefly in fast ice, and in several Finnish lakes. Four geographically isolated peripheral populations are fairly well-defined subspecies, one each from the Okhotsk Sea (*P. h. ochotensis* Pallas, 1811); the Baltic Sea (*P. h. botnica* Gmelin, 1788); Lake Ladoga (*P. h. ladogensis* Nordquist, 1899); and Lake Saimaa and adjacent lakes (*P. h. saimensis* Nordquist, 1899). Geographical variation in the Arctic Ocean and Bering Sea populations, tentatively referable to the nominate subspecies, requires much further study.

Phoca sibirica Gmelin, 1788 (Baikal seal).
Only in Lake Baikal, U.S.S.R., a freshwater body which freezes in winter.

Phoca caspica Gmelin, 1788 (Caspian seal).
Only in Caspian Sea, U.S.S.R., the northern end of which freezes in winter.

Phoca groenlandica Erxleben, 1777 (harp seal).
North Atlantic Ocean, in pack ice from northern shores of Europe to eastern Canada. Breeds on pack ice in three main areas: the White Sea, north of Jan Mayen, and Newfoundland. (The Newfoundland seals breed in two centers: the "Front" north of the island and the "Gulf" west of it.) Seals of the three areas differ in size, cranial features, and body coloration (Khuzin 1963, 1967; Yablokov and Sergeant 1963; Yablokov and Etin 1965). Subspecific names have been given to the Newfoundland stock, *P. g. groenlandica*, and that of the White Sea, *P. g. oceanica* Lepechin, 1778, but not to the Jan Mayen stock (Smirnov 1927).

Phoca fasciata Zimmermann, 1783 (ribbon seal).
North Pacific Ocean, chiefly in pack ice, from northern Hokkaido and the Okhotsk Sea to northwestern Alaska.

Genus HALICHOERUS Nilsson, 1820

Halichoerus grypus (Fabricius, 1791) (gray seal).
Temperate coasts of the North Atlantic. There are three breeding populations: one in the western Atlantic from Newfoundland to Massachusetts, another in the eastern Atlantic from the British Isles (rarely France) and Iceland to the White Sea, and a third in the Baltic Sea. Seals of the western Atlantic and Baltic populations pup in February and March, seals of the eastern Atlantic from September to December.

Genus ERIGNATHUS Gill, 1866

Erignathus barbatus (Erxleben, 1777) (bearded seal).
Circumboreal at edges of ice; along all coasts and islands of northern Eurasia and northern North America. No subspecies are recognizable (Kosygin and Potelov 1971).

Genus CYSTOPHORA Nilsson, 1820

Cystophora cristata (Erxleben, 1777) (hooded seal; bladdernose seal).
North Atlantic Ocean at edges of ice from Novaya Zemlya to eastern Canada. Jan Mayen, Newfoundland, and Davis Strait breeding stocks are perhaps distinct.

Genus MONACHUS Fleming, 1822

Monachus monachus (Hermann, 1779) (Mediterranean monk seal).
The original range included the southern and western coasts of the Black Sea, the coasts and islands of the Mediterranean Sea, the coast of northwestern Africa southwestward to Cape Blanc, Mauritania, and the Madeira and Canary islands. Now rare or extirpated throughout much of its range.

Monachus tropicalis (Gray, 1850) (Caribbean monk seal; West Indian monk seal).
Extinct (K. W. Kenyon, pers. commun.). In historic times its range included shores and islands of the western Caribbean Sea, the Greater Antilles, the northern Lesser Antilles, the Bahamas, the Yucatan Peninsula, and the Florida Keys. In prehistoric times ranged north to South Carolina.

Monachus schauinslandi Matschie, 1905 (Hawaiian monk seal).
Breeds on Leeward Chain of the Hawaiian Islands, from French Frigate Shoals to Kure Atoll; rarely wanders southeastward to Hawaii and south to Johnston Island.

Genus LOBODON Gray, 1844

Lobodon carcinophagus (Hombron and Jacquinot, 1842) (crabeater seal).
Crabeaters are circumpolar and abundant in pack ice of the Southern Ocean; they straggle to southern tips of New Zealand, Australia, Tasmania, South Africa, and South America.

Genus OMMATOPHOCA Gray, 1844

Ommatophoca rossii Gray, 1844 (bigeye seal; Ross seal).
Circumpolar in pack ice of Antarctic Ocean.

Genus HYDRURGA Gistel, 1848

Hydrurga leptonyx (de Blainville, 1820) (leopard seal).
Leopard seals are circumpolar in the Southern Ocean and are recorded from most subantarctic islands, as well as New Zealand, southern Australia, the Cook Islands, southern South America, and South Africa.

Genus LEPTONYCHOTES Gill, 1872

Leptonychotes weddelli (Lesson, 1826) (Weddell seal).
Circumpolar in fast ice around Antarctica, south to lat. 80°S in the Bay of Whales; straggling to subantarctic islands and as far north as Uruguay, lat. 35°S.

Genus MIROUNGA Gray, 1827

Mirounga leonina (Linnaeus, 1758) (southern elephant seal).
Circumpolar on subantarctic islands, south to edges of ice at lat. 78°S. The southern elephant seal breeds along a continental coast only at Argentina. Three subspecies have been proposed, one from the South American sector of the range, one from the southern Indian Ocean sector, and one from the New Zealand sector (Lydekker 1909). They may be valid, but further study is required before they can be accepted.

Mirounga angustirostris (Gill, 1866) (northern elephant seal).
Breeds from the Farallon Islands, Calif., south to Isla Guadalupe and Islas San Benito, Baja California. Formerly from Point Reyes, Calif., south to Cabo San Lázaro, Baja California. Ranges at sea north to southeastern Alaska.

Order SIRENIA

Family DUGONGIDAE

Genus DUGONG Lacépède, 1799

Dugong dugon (Müller, 1776) (dugong).
In tropical bays and estuaries of the Indian and western Pacific oceans from Lourenço Marques, Mozambique, and the Red Sea, east to the Ryukyu Islands (Amami Oshima), Palau, the Solomon Islands, the New Hebrides, New Caledonia, the Fiji Islands, and northern Australia. Carter et al. (1945) listed it from the Marshall Islands; if it ever occurred there it no longer does so. Now rare in all its range except along northern Australia.

Genus HYDRODAMALIS Retzius, 1794

Hydrodamalis gigas (Zimmermann, 1780) (great northern sea cow; Steller's sea cow).
Discovered in the Commander Islands in 1741, the sea cow was exterminated by Russian hunters about 1768. In historic time, it lived only on Bering and Copper islands and its total population probably did not exceed 1,000 or 2,000 animals. A rib was found on Attu, the westernmost Aleutian Island, in 1842 or 1843, by Ilia G. Wosnesenski. "There is no indisputable evidence of its ever having inhabited other coasts than those of the Commander Islands, as the find of a rib on Attu Island does not necessarily

prove that the animal once lived there, though that is not improbable" (Stejneger 1897). A skull fragment about 19,000 yr old was dredged from the sea floor off Monterey, Calif. (Jones 1967). Remains have also been recovered from Pleistocene deposits on Amchitka in the Aleutian Islands (Gard 1972). Recent rumors (Berzin et al. 1963) of living sea cows near Cape Navarin, Siberia, have been discredited.

Family TRICHECHIDAE

Genus TRICHECHUS Linnaeus, 1758

Three allopatric species are recognized (Hatt 1934), but their status needs confirmation.

Trichechus manatus Linnaeus, 1758 (Caribbean manatee; West Indian manatee).

Two doubtfully valid subspecies have been described: *T. m. manatus* from the sea coast, and lower reaches of rivers, from Bay of Campeche, Mexico, to northeastern South America, and in the Bahamas and the Greater Antilles; and *T. m. latirostris* (Harlan 1824) from the coast and coastal rivers of United States from Beaufort, N.C., to Florida Keys and coast of Gulf of Mexico, westward to mouth of Rio Grande.

Trichechus senegalensis Link, 1795 (West African manatee).

Coastal lagoons and the lower reaches of rivers from Sénégal to the Cuanza River, Angola, and in the Niger and Benue drainages of Nigeria.

Trichechus inunguis (Natterer, 1883) (Amazon manatee).

Rivers of northeastern South America, particularly the Amazon and Orinoco systems.

Order MYSTICETI

Family ESCHRICHTIIDAE

Genus ESCHRICHTIUS Gray, 1864

Eschrichtius robustus (Lilljeborg, 1861) (gray whale).

Shallow coastal waters of the North Pacific. There are two stocks, one on the eastern side from the Gulf of California to the Chukchi and Beaufort seas, another on the western side from Korea and Japan to the Okhotsk Sea; the latter stock is nearly extinct. Formerly in the North Atlantic.

Family BALAENOPTERIDAE

Genus BALAENOPTERA Lacépède 1804

Balaenoptera acutorostrata Lacépède, 1804 (minke whale).

Widely distributed in all oceans. Three subspecies are recognizable: *B. a. acutorostrata* in the North Atlantic, *B. a. davidsoni* Scammon, 1872, in the North Pacific, and *B. a. bonaerensis* Burmeister, 1867, in the Southern Hemisphere (Omura 1975). Specimens from Ceylon have also been described as a separate subspecies, *B. a. thalmaha* Deraniyagala, 1963, but its validity requires confirmation.

Balaenoptera edeni Anderson, 1878 (Bryde whale).

Tropical and warm temperate waters of the Atlantic, Indian, and Pacific oceans.

Balaenoptera borealis Lesson, 1828 (sei whale).

All oceans except tropical and polar seas. Two subspecies distinguished: a smaller one, *B. b. borealis*, in the Northern Hemisphere and a larger one, *B. b. schlegellii* Flower, 1865, in the Southern Hemisphere.

Balaenoptera physalus (Linnaeus, 1758) (fin whale).

All oceans, but rarely in tropical waters or among pack ice. Two subspecies are recognized: a smaller Northern Hemisphere form, *B. p. physalus*, and a larger Southern Hemisphere form, *B. p. quoyi* (Fischer, 1829).

Balaenoptera musculus (Linnaeus, 1758) (blue whale).

All oceans. Three subspecies are recognized: a small one, *B. m. musculus*, in the North Atlantic and North Pacific; a large one, *B. m. intermedia* Burmeister, 1871, that spends the summer in Antarctic waters; and a pygmy subspecies, *B. m. brevicauda* Ichihara, 1966, in the southern Indian Ocean. (The name *B. m. brevicauda*, published by Zemsky and Boronin 1964, is a nomen nudum according to van Bree, pers. commun.; the first valid publication of the name was by Ichihara 1966.) The taxonomic status of blue whales off the coasts of Chile and Peru and in the northern Indian Ocean is not settled.

Genus MEGAPTERA Gray, 1846

Megaptera novaeangliae (Borowski, 1781) (humpback whale).

Nearly worldwide; winters largely in tropical waters near islands or the coast, summers in temperate and subpolar waters. This species shows little or no geographical variation in size; the several discrete populations differ in the frequency of color variations.

Family BALAENIDAE

Genus BALAENA Linnaeus, 1758

Some authors place *glacialis* in a separate genus, *Eubalaena* Gray, 1864. Eschricht and Reinhardt (1861), the only authors who have made a detailed comparison between *mysticetus* and *glacialis*, regarded them as congeneric. Gray's generic name was ignored by virtually all subsequent authors until it was resurrected by Allen

(1908). Gray and Allen were two of the most notorious generic "splitters" in the history of mammalogy (cf. Simpson 1961:139). The differences between the two species are no greater than those separating, e.g., the various species of *Balaenoptera*.

Balaena glacialis Müller, 1776 (right whale; black right whale).
Temperate waters of the North Atlantic, the North Pacific, and the Southern Hemisphere. The southern populations are distinguishable as a separate subspecies (or species, according to some authors), *B. g. australis* Desmoulins, 1822, from *B. g. glacialis* of the North Atlantic (Muller 1954); North Pacific populations are apparently identical to those of the North Atlantic (Omura et al. 1969).

Balaena mysticetus Linnaeus, 1758 (bowhead whale; Arctic right whale).
Arctic waters. There are four geographically isolated populations: 1) From Spitzbergen west to east Greenland; 2) in Davis Strait, Baffin Bay, James Bay, and adjacent waters; 3) in the Bering, Chukchi, and Beaufort seas; and 4) in the Okhotsk Sea. The Alaskan Eskimo recognize two kinds: the larger "kairalik" or true bowhead, and the smaller "ingotok" (known as the "poggy" to the 19th century American whalers). I believe that the ingotok is most likely a young bowhead.

Genus CAPEREA Gray, 1864

Caperea marginata (Gray, 1846) (pygmy right whale).
Temperate waters of Southern Ocean; known mostly from strandings on New Zealand, Australia, South America, the Falkland Islands, and South Africa.

Order ODONTOCETI

In recent years, several new family classifications of the odontocetes have been proposed (Fraser and Purves 1960; Nishiwaki 1963; Kasuya 1973). I believe that insufficient evidence has been published to support the validity of these classifications and that much more study is needed before any changes will be generally accepted. I therefore follow tradition in regarding the living odontocetes as divisible into five families.

Family PLATANISTIDAE

This family includes three well-marked subfamilies (which are sometimes accorded family rank): Platanistinae (*Platanista*), Iniinae (*Inia, Lipotes*), and Pontoporiinae (*Pontoporia*).

Genus INIA d'Orbigny, 1834

Inia geoffrensis (de Blainville, 1817) (bouto; Amazon dolphin).
Amazon and Orinoco basins of South America. *Inia g. boliviensis* d'Orbigny, 1834, of the upper Madeira River system in Bolivia differs considerably from *I. g. geoffrensis* in the remainder of the Amazon basin and may be a distinct species (van Bree and Robineau 1973; van Bree, pers. commun.). The population in the Orinoco basin may also be subspecifically distinct.

Genus LIPOTES Miller, 1918

Lipotes vexillifer Miller, 1918 (pei c'hi; whitefin dolphin).
Lower Yangtze River from its mouth (Shanghai) upstream to Tung-t'ing Hu (Lake) and its tributaries. The English name "whiteflag" dolphin is based on an erroneous interpretation of the Chinese (M. Nishiwaki, pers. commun.).

Genus PONTOPORIA Gray, 1846

Pontoporia blainvillei (Gervais and d'Orbigny, 1844) (franciscana; La Plata dolphin).
Coastal waters and estuaries of eastern South America, from Baia de Santos, Brazil, to Golfo San Matias, Argentina.

Genus PLATANISTA Wagler, 1830

The two allopatric forms of this genus are regarded as subspecifically distinct by Kasuya (1972) and as specifically distinct by Pilleri and Gihr (1971). I tentatively list them as separate species on the advice of van Bree (pers. commun.).

Platanista gangetica (Roxburgh, 1801) (Ganges susu; Ganges dolphin).
Ganges-Brahmaputra-Meghna river system of India, Bangladesh, and Nepal, from tidal limits to the foothills. It is presumably this species that formerly occurred in the Karnaphuli River.

Plantanista minor Owen, 1853 (Indus susu; Indus dolphin).
Indus River system of Pakistan and India, from tidal limits to the foothills. (Most authors have used the name *P. indi* Blyth, 1859, but Owen's name has priority.)

Family DELPHINIDAE

Basic references on the classification of the Delphinidae are Flower (1883) and True (1889). The true porpoises (*Phocoena, Neophocaena*, and *Phocoenoides*) constitute a well-marked group that is sometimes accorded family rank (Phocoenidae). The remainder of the family has been variously subdivided or divided.

Genus STENO Gray, 1846

Steno bredanensis (Lesson, 1828) (rough-toothed dolphin.)
All tropical and warm temperate seas.

Genus SOUSA Gray, 1866

Sousa chinensis (Osbeck, 1765) (Indo-Pacific humpback dolphin; white dolphin).

Coastal waters of the Indian and western Pacific oceans, from Port Elizabeth, South Africa, north to the Red Sea and east to southern China (including lower reaches of the Yangtze, Foochow, and Canton rivers), Borneo, and northeastern and eastern Australia. The taxonomy of the humpbacked dolphins is greatly in need of revision. Several nominal species have been described, but individual, sexual, age, and geographic variations have not been adequately studied.

Sousa teuszii (Kükenthal, 1892) (Atlantic humpback dolphin).

Coastal waters of west Africa from Mauritania to Cameroon. This form could perhaps be regarded as a subspecies of *S. chinensis*, from which it differs mainly in tooth count (26-29 versus 32-36).

Genus SOTALIA Gray, 1866

Further taxonomic studies of this genus are needed. Two forms are recognized—one chiefly in coastal and estuarine waters, the other in fresh water. The differences between them are slight; they are best regarded as subspecies of a single species. (The Old World species formerly placed in *Sotalia* are now placed in a separate genus, *Sousa*.)

Sotalia fluviatilis (Gervais, 1853) (tucuxi; tookashee).

Sotalia f. fluviatilis occurs in the Amazon River and its tributaries; *S. f. guianensis* (van Beneden, 1864) occurs in coastal waters and lower reaches of rivers of northeastern South America, from Lake Maracaibo, Venezuela, to Santos, Brazil.

Genus TURSIOPS Gervais, 1855

Tursiops truncatus (Montagu, 1821) (bottlenose dolphin).

Widely distributed in temperate and tropical waters, including the Black Sea. Occurs mostly close to shore, near islands, and over shallow banks. Ranges north to Japan, Hawaii, California, New Brunswick, and Norway; south to southern Australia, New Zealand, Chile, Argentina, and South Africa. There is considerable geographical variation; populations in warmer waters of the Indo-Pacific tend to average smaller in body size and greater in snout length and tooth count.

Genus STENELLA Gray, 1866

The species of this genus fall into three groups or superspecies which are sympatric in many areas: 1) The spinner dolphins with long snouts, about 50 teeth in each jaw, and shallow palatal grooves. This group includes forms that differ markedly in body form and color pattern, but intermediate populations connect the extreme forms, so they are regarded as conspecific (Perrin 1972, 1975a, b). Current studies indicate, however, that there is probably another species in the Atlantic similar to, but sympatric with, the spinner dolphin (Perrin, pers. commun.). 2) The spotted and bridled dolphins with shorter snouts, about 37 teeth in each jaw, and no palatal grooves. This group apparently includes two species, the ranges of which overlap in the Atlantic (Perrin 1975b). 3) The striped dolphins, with about 44 teeth in each jaw, no palatal grooves, a dark stripe along the flank, and no spots. Only one species is recognized (Fraser and Noble 1970).

Stenella longirostris (Gray, 1828) (spinner dolphin).

Tropical Atlantic, Indian, and Pacific oceans. This species shows marked geographical variation. In the central and eastern Pacific, Perrin (1972, 1975a, b) has described four subspecies: "Costa Rican," "eastern," "whitebelly," and "Hawaiian"—the correct scientific names of which have not been determined. [Although most recent authors have used Gray's specific name, its applicability is questionable (Perrin 1975b).]

Stenella attenuata (Gray, 1846) (bridled dolphin; pantropical spotted dolphin).

Tropical Atlantic, Indian, and Pacific oceans. This species also shows considerable geographical variation. In the central and eastern Pacific, Perrin (1970, 1975a, b) has described three subspecies: "coastal" *S. a graffmani* (Lönnberg, 1934), "offshore," and "Hawaiian"; the correct scientific names of the latter two have not been determined. [For the spotted dolphins I provisionally use the specific names employed by most recent authors, although their validity is dubious. Other available names are *S. dubia* (G. Cuvier, 1812) and *S. frontalis* (G. Cuvier, 1829).]

Stenella plagiodon (Cope, 1866) (spotted dolphin; Atlantic spotted dolphin).

Tropical and warm temperate waters of Atlantic Ocean. (See nomenclatorial note under preceding species).

Stenella coeruleoalba (Meyen, 1833) (striped dolphin).

Widely distributed in temperate and tropical waters around the world.

Genus DELPHINUS Linnaeus, 1758

Delphinus delphis Linnaeus, 1758 (saddleback dolphin).

Widely distributed in warm temperate and tropical waters of all oceans, including the Black Sea. There is marked geographical variation in snout length and other features; the extremely longsnouted Arabian Sea form, *D. d. tropicalis* van Bree, 1971, may be a distinct species (van Bree and Purves 1972).

Genus LAGENODELPHIS Fraser, 1956

Lagenodelphis hosei Fraser, 1956 (shortsnouted whitebelly dolphin).
Tropical and warm temperate waters of Indian and Pacific oceans. Recorded from Natal, Japan, Taiwan, Philippines, Borneo, northeastern Australia, and the central and eastern tropical Pacific.

Genus LAGENORHYNCHUS Gray, 1846

This genus contains two well-defined species in the North Atlantic and another in the North Pacific. Bierman and Slijper (1947, 1948) regarded all Southern Hemisphere forms as conspecific, but Fraser (1966) showed that there are three distinct species. The species *electra* is now placed in a separate genus, *Peponocephala*.

Lagenorhynchus albirostris (Gray, 1846) (whitebeak dolphin).
North Atlantic from Davis Strait and Newfoundland east to the Barents Sea and North Sea (rarely to the southern British Isles).

Lagenorhynchus acutus (Gray, 1828) (Atlantic whiteside dolphin).
North Atlantic from Massachusetts and southern Greenland east to western Norway and the British Isles.

Lagenorhynchus obliquidens Gill, 1865 (Pacific whiteside dolphin; hookfin dolphin).
Waters off the coast of North America from southeastern Alaska to Baja California, and off the coast of Asia from the Kuril Islands to Japan.

Lagenorhynchus obscurus (Gray, 1828) (dusky dolphin).
Temperate waters off South America, South Africa, Kerguélen Island, southern Australia, and New Zealand. Primarily a coastal species.

Lagenorhynchus australis (Peale, 1848) (blackchin dolphin).
Temperate waters off southern South America and the Falkland Islands.

Lagenorhynchus cruciger (Quoy and Gaimard, 1824) (hourglass dolphin).
Temperate waters of the Southern Ocean. A pelagic species, found chiefly in waters immediately north of the Antarctic Convergence.

Genus CEPHALORHYNCHUS Gray, 1846

Four species are recognized (Harmer 1922).

Cephalorhynchus commersonii (Lacépède, 1804) (piebald dolphin; Jacobite).
Atlantic coast of South America from Golfo San Matias to Tierra del Fuego; Falkland Islands; South Georgia; and Kerguélen Island.

Cephalorhynchus eutropia (Gray, 1846) (black dolphin; Chilean dolphin).
Coast of Chile between lat. 37° and 55°S.

Cephalorhynchus heavisidii (Gray, 1828).
Coastal waters from Cape of Good Hope north to Cape Cross, South West Africa (P. B. Best, pers. commun.).

Cephalorhynchus hectori (van Beneden, 1881) (pied dolphin; whitefront dolphin).
Coastal waters of New Zealand.

Genus LISSODELPHIS Gloger, 1841

The two species of this genus differ, as far as is known, mainly in color pattern, and they should perhaps be regarded as subspecies of a single species.

Lissodelphis borealis (Peale, 1848) (northern rightwhale dolphin).
Temperate waters of the North Pacific from Japan and the Kurils to British Columbia and California. Individuals from Japan with a variant color pattern have been named *L. b. albiventris* Nishiwaki, 1972.

Lissodelphis peronii (Lacépède, 1804) (southern rightwhale dolphin).
Temperate waters of the Southern Ocean.

Genus GRAMPUS Gray, 1828

Grampus griseus (G. Cuvier, 1812) (whitehead grampus; gray grampus).
All temperate and tropical seas.

Genus PEPONOCEPHALA Nishiwaki and Norris, 1966

Peponocephala electra (Gray, 1846) (little blackfish; many-toothed blackfish; melon-head blackfish).
Tropical Atlantic, Indian, and Pacific oceans.

Genus FERESA Gray, 1871

Feresa attenuata Gray, 1875 (pygmy killer whale).
Tropical and warm temperate waters of the Atlantic, Indian, and Pacific oceans.

Genus PSEUDORCA Reinhardt, 1862

Pseudorca crassidens (Owen, 1846) (false killer whale).
All temperate and tropical seas.

Genus GLOBICEPHALA Lesson, 1828

There appear to be two well-defined species, the ranges of which overlap off the middle Atlantic coast of the United States, off southern Europe, off South Africa, and perhaps elsewhere (van Bree 1971).

Globicephala melaena (Traill, 1809) (longfin pilot whale).
Nominate subspecies in the cool temperate North Atlantic Ocean; *G. m. edwardii* A. Smith, 1834, throughout cool temperate waters of the Southern Hemisphere. The validity of the subspecific distinction is questionable. Occurred in the North Pacific (near Japan) until at least the 10th century A.D. (Kasuya 1975).

Globicephala macrorhynchus Gray, 1846 (shortfin pilot whale).
Tropical and warm temperate waters of the Atlantic, Indian, and Pacific oceans. *Globicephala sieboldii* Gray, 1846, of the North Pacific is conspecific with *G. macrorhynchus*, although it may be recognizable at the subspecific level. (The specific name is usually spelled *macrorhyncha*, but it is a noun in apposition, not an adjective, so must retain its original gender.)

Genus ORCINUS Fitzinger, 1860

Orcinus orca (Linnaeus, 1758) (killer whale).
All oceans, chiefly in coastal waters and cooler regions.

Genus ORCAELLA Gray, 1866

Orcaella brevirostris (Gray, 1866) (Irrawaddy dolphin; lumbalumba).
Coastal waters from the Bay of Bengal east to New Guinea and northern Australia; ascends far up the Mekong, Irrawaddy, Ganges, and other rivers.

Genus PHOCOENA G. Cuvier, 1817

The genus includes four species (Norris and McFarland 1958; Noble and Fraser 1971).

Phocoena phocoena (Linnaeus, 1758) (harbor porpoise).
Coastal waters of the North Atlantic from Delaware and Sénégal north to Davis Strait, Iceland, and the White Sea; coastal waters of the North Pacific from Japan and Baja California north to Point Barrow, Alaska. An isolated population in the Black Sea has been named *P. p. relicta* Abel, 1905.

Phocoena sinus Norris and McFarland, 1958 (vaquita; cochito; Gulf of California porpoise).
Upper Gulf of California; sight records farther south are questionable.

Phocoena dioptrica Lahille, 1912 (spectacled porpoise).
Coast of Argentina and Uruguay; the Falkland Islands; and South Georgia.

Phocoena spinipinnis Burmeister, 1865 (black porpoise).
East coast of South America from Uruguay to Patagonia; west coast from Paita, Peru, to Valdivia, Chile.

Genus NEOPHOCAENA Palmer, 1899

Neophocaena phocaenoides (G. Cuvier, 1829) (finless porpoise).
Warm coastal waters and certain rivers from Pakistan east to Korea, Japan, Borneo, and Java. (The type-specimen allegedly came from the Cape of Good Hope, but Peter Best (pers. commun.) stated that there are no indisputable South African records.) Specimens from China and Japan differ from Indian Ocean specimens, and are best regarded as a subspecies, *N. p. asiaeorientalis* (Pilleri and Gihr, 1971), rather than a full species as originally described (van Bree 1973). More recently Pilleri and Gihr (1975) have differentiated three allopatric forms which they arbitrarily rank as species: *N. phocaenoides* from Pakistan to Borneo, *N. asiaeorientalis* from China, and *N. sunameri* Pilleri and Gihr, 1975, from Japan and Korea. Their published data are inadequate to reveal whether the Japanese and Chinese populations are sufficiently separable to warrant recognition of *sunameri* even as a subspecies.

Genus PHOCOENOIDES Andrews, 1911

Phocoenoides dallii (True, 1885) (Dall porpoise; whiteflank porpoise).
Immediate offshore waters of the North Pacific from Japan and southern California north to the southern Bering Sea. "True's porpoise" is a color phase localized in Japanese waters.

Family MONODONTIDAE

Some authors have included the narwhal and beluga in the family Delphinidae.

Genus DELPHINAPTERUS Lacépède, 1804

Delphinapterus leucas (Pallas, 1776) (beluga; belukha; white whale).
Arctic Ocean and adjacent seas; including Okhotsk and Bering Seas, and James Bay; isolated populations occur in Cook Inlet, Alaska, and the Gulf of St. Lawrence; ascends several hundred miles up larger rivers of Siberia and Alaska. Some authors recognize three subspecies: a large one, *D. l. dorofeevi* Barabash and Klumov, 1935, from the

Okhotsk Sea; a small one, *D. l. marisalbi* Ostroumov, 1935, in the Barents and White seas; and a medium-sized one, *D. l. leucas,* in the rest of the range. However, geographical variation is more complex than this classification suggests (Sergeant and Brodie 1969).

Genus MONODON Linnaeus, 1758

Monodon monoceros Linnaeus, 1758 (Narwhal).
North polar seas, mainly in deep waters.

Family PHYSETERIDAE

The genus *Kogia* is sometimes placed in a separate family (Kogiidae).

Genus PHYSETER Linnaeus, 1758

Physeter macrocephalus Linnaeus, 1758 (sperm whale).
All oceans (except polar ice fields). (For use of this name instead of *P. catodon* Linnaeus, 1758, see Husson and Holthuis 1974.)

Genus KOGIA Gray, 1846

Handley (1966) has reviewed the distinguishing features of the two species in this genus.

Kogia breviceps (de Blainville, 1838) (pygmy sperm whale).
World-wide in tropical and warm temperate waters.

Kogia simus Owen, 1866 (dwarf sperm whale).
The seas adjacent to South Africa, India, Ceylon, Japan, Hawaii, California, Baja California, and eastern United States.

Family ZIPHIIDAE

See Moore (1968) for diagnoses of the genera.

Genus BERARDIUS Duvernoy, 1851

Two allopatric species are recognized. The North Pacific form differs from the Southern Hemisphere form chiefly by its much larger size. Possibly it should be regarded as only a subspecies of the Southern Hemisphere form.

Berardius arnuxii Duvernoy, 1851 (southern giant bottlenose whale).
Southern Ocean; known from South Australia, New Zealand, Argentina, Falkland Islands, South Georgia, South Shetlands, South Africa, and off the Antarctic Peninsula.

Berardius bairdii Stejneger, 1883 (North Pacific giant bottlenose whale).
North Pacific from Japan and southern California north to the Bering Sea.

Genus ZIPHIUS G. Cuvier, 1823

Ziphius cavirostris G. Cuvier, 1823 (goosebeak whale).
All temperate and tropical seas.

Genus TASMACETUS Oliver, 1937

Tasmacetus shepherdi Oliver, 1937.
Known only from a few specimens stranded in New Zealand, Chile, and Argentina.

Genus INDOPACETUS Moore, 1968

The one species of this genus was formerly included in *Mesoplodon*.

Indopacetus pacificus (Longman, 1926) (Indo-Pacific beaked whale).
Known from only two specimens stranded at Mackay, Queensland, Australia, and Danane, Somalia.

Genus HYPEROODON Lacépède, 1804

Two well-defined species are recognized: one in the North Atlantic, the other in the Southern Hemisphere. The latter constitutes subgenus *Frasercetus* Moore, 1968. The occurrence of *Hyperoodon* in the North Pacific has never been verified, and most if not all published records of its occurrence there are based on misidentification of *Berardius*. Beaked whales possibly referable to *Hyperoodon* are taken by whalers off the Okhotsk Sea coast of Hokkaido, but to date none has been examined by a biologist (M. Nishiwaki, pers. commun.).

Hyperoodon ampullatus (Forster, 1770) (North Atlantic bottlenose whale).
North Atlantic from Davis Strait and Novaya Zemlya south to Rhode Island and the English Channel; doubtfully recorded from the Mediterranean Sea.

Hyperoodon planifrons Flower, 1882 (flathead bottlenose whale).
Southern Ocean; known from Australia, New Zealand, Argentina, the Falkland Islands, South Georgia, the South Orkney Islands, South Africa, and off the coast of Antarctica in the Pacific and Indian Ocean sectors.

Genus MESOPLODON Gervais, 1850

Eleven species are currently recognized by Moore (1968). *Mesoplodon pacificus* is now placed in a separate genus, *Indopacetus. Mesoplodon layardii* is placed in the subgenus *Dolichodon* Gray, 1871; *M. densirostris* in the subgenus *Dioplodon* Gervais, 1850; and the remaining species are placed in subgenus *Mesoplodon*.

Mesoplodon hectori (Gray, 1871).
Known only from Tasmania, New Zealand, the Falkland Islands, and South Africa.

Mesoplodon mirus True, 1913.
North Atlantic from Florida and Nova Scotia east to the British Isles; an apparently isolated population in temperate waters off South Africa.

Mesoplodon europaeus (Gervais, 1855) (Antillean beaked whale; Gulf Stream beaked whale).
Western North Atlantic from Trinidad, Jamaica, and the Gulf of Mexico, to Long Island, N.Y.; one record from the English Channel.

Mesoplodon ginkgodens Nishiwaki and Kamiya, 1958 (ginkgo-tooth whale).
Recorded from Ceylon, Taiwan, Japan, and California.

Mesoplodon grayi von Haast, 1876 (scamperdown whale).
South Africa, South Australia, New Zealand, Chatham Islands, and Argentina; one record from the Netherlands.

Mesoplodon carlhubbsi Moore, 1963 (archbeak whale).
Temperate waters of the North Pacific from Japan east to British Columbia and California.

Mesoplodon bowdoini Andrews, 1908 (deepcrest whale).
Known only from New Zealand, Tasmania, Western Australia, Victoria, and Kerguélen Island.

Mesoplodon stejnegeri True, 1885 (sabertooth whale; Bering Sea beaked whale).
Subarctic waters of the North Pacific from the Bering Sea south to Japan and Oregon.

Mesoplodon bidens (Sowerby, 1804) (North Sea beaked whale).
Cool temperate waters of the North Atlantic from Newfoundland and Massachusetts east to southern Norway and the Bay of Biscay.

Mesoplodon layardii (Gray, 1865) (straptooth whale).
South Africa, southern Australia, New Zealand, and the Falkland Islands.

Mesoplodon densirostris (de Blainville, 1817) (densebeak whale; tropical beaked whale).
Tropical and warm temperate waters of all oceans.

SYNONYMS

Listed below are generic and specific synonyms frequently appearing in recent literature.

In recent literature	In present list
Arctocephalus doriferus	*Arctocephalus pusillus*
A. elegans	*A. tropicalis*
A. tasmanicus	*A. pusillus*
Arctophoca	*Arctocephalus*
Balaena australis	*Balaena glacialis*
B. japonica	*B. glacialis*
B. sieboldii	*B. glacialis*
Balaenoptera bonaerensis	*Balaenoptera acutorostrata*
B. brydei	*B. edeni*
B. davidsoni	*B. acutorostrata*
B. huttoni	*B. acutorostrata*
Callorhinus alascensis	*Callorhinus ursinus*
C. curilensis	*C. ursinus*
C. cynocephalus	*C. ursinus*
C. mimicus	*C. ursinus*
Cephalorhynchus albifrons	*Cephalorhynchus hectori*
C. albiventris	*C. eutropia*
Delphinapterus dorofeevi	*Delphinapterus leucas*
D. friemani	*D. leucas*
Delphinus bairdii	*Delphinus delphis*
D. capensis	*D. delphis*
D. dussumieri	*D. delphis*
D. longirostris	*D. delphis*
D. roseiventris	*Stenella longirostris*
D. tropicalis	*Delphinus delphis*
Electra	*Peponocephala*
Eschrichtius gibbosus	*Eschrichtius robustus*
E. glaucus	*E. robustus*
Eubalaena	*Balaena*
Eumetopias stellerii	*Eumetopias jubatus*
Feresa intermedia	*Feresa attenuata*
F. occulta	*F. attenuata*
Globicephala brachyptera	*Globicephala macrorhynchus*
G. edwardii	*G. melaena*
G. leucosagmaphora	*G. melaena*
G. scammonii	*G. macrorhynchus*
G. sieboldii	*G. macrorhynchus*
Grampidelphis	*Grampus*
Grampus orca	*Orcinus orca*
G. rectipinna	*O. orca*
Gypsophoca	*Arctocephalus*
Histriophoca	*Phoca*
Hydrodamalis stelleri	*Hydrodamalis gigas*
Hyperoodon rostratus	*Hyperoodon ampullatus*
Lagenorhynchus electra	*Peponocephala electra*
L. fitzroyi	*Lagenorhynchus obscurus*
L. ognevi	*L. obliquidens*
L. superciliosus	*L. obscurus*
L. thicolea	*Lagenorhynchus* sp.?
L. wilsoni	*L. cruciger*
Megaptera nodosa	*Megaptera novaeangliae*
Meomeris	*Neophocaena*
Mesoplodon gervaisi	*Mesoplodon europaeus*
M. hotaula	*M. gingkodens*
M. pacificus	*Indopacetus pacificus*

Monachus albiventer	*Monachus monachus*
Neobalaena	*Caperea*
Neomeris	*Neophocaena*
Neophoca hookeri	*Phocarctos hookeri*
N. lobatus	*Neophoca cinerea*
Nodus	*Mesoplodon*
Odobenus divergens	*Odobenus rosmarus*
Orcaella fluminalis	*Orcaella brevirostris*
Orcella	*Orcaella*
Orcinus rectipinna	*Orcinus orca*
Otaria byronia	*Otaria flavescens*
Pagophilus	*Phoca*
Phoca insularis	*Phoca vitulina*
P. kurilensis	*P. vitulina*
P. richardii	*P. vitulina*
Phocoena vomerina	*Phocoena phocoena*
Phocoenoides truei	*Phocoenoides dallii*
Physeter catodon	*Physeter macrocephalus*
Platanista indi	*Platanista minor*
Prodelphinus	*Stenella*
Pusa	*Phoca*
Rhachianectes	*Eschrichtius*
Rhytina	*Hydrodamalis*
Sibbaldus	*Balaenoptera*
Sotalia borneensis	*Sousa chinensis*
S. brasiliensis	*Sotalia fluviatilis*
S. chinensis	*Sousa chinensis*
S. gadamu	*Tursiops truncatus*
S. guianensis	*Sotalia fluviatilis*
S. lentiginosa	*Sousa chinensis*
S. pallida	*Sotalia fluviatilis*
S. plumbea	*Sousa chinensis*
S. sinensis	*S. chinensis*
S. teuszii	*S. teuszii*
S. tucuxi	*Sotalia fluviatilis*
Sousa borneensis	*Sousa chinensis*
S. lentiginosa	*S. chinensis*
S. plumbea	*S. chinensis*
S. queenslandensis	*S. chinensis*
Stenella alope	*Stenella longirostris*
S. dubia	*Stenella* (?) *attenuata*
S. euphrosyne	*S. coeruleoalba*
S. frontalis	*Stenella* (?) *attenuata*
S. graffmani	*S. attenuata*
S. malayana	*Sousa chinensis* (fide van Bree, pers. commun.)
S. microps	*Stenella longirostris*
S. pernettensis	*Stenella* (?) *plagiodon*
S. roseiventris	*S. longirostris*
S. styx	*S. coeruleoalba*
Steno rostratus	*Steno bredanensis*
Stenodelphis	*Pontoporia*
Stenorhinchus	*Hydrurga*
Stenorhynchus	*Hydrurga*
Susu	*Platanista*
Thalarctos	*Ursus*
Trichechus latirostris	*Trichechus manatus*
Tursiops abusalum	*Tursiops truncatus*
T. aduncus	*T. truncatus*
T. catalania	*T. truncatus*
T. gadamu	*T. truncatus*
T. gillii	*T. truncatus*
T. nesarnack	*T. truncatus*
T. nuuanu	*T. truncatus*
Zalophus cinereus	*Neophoca cinerea*
Z. japonicus	*Zalophus californianus*
Z. lobatus	*Neophoca cinerea*
Z. wollebaeki	*Zalophus californianus*

ACKNOWLEDGMENTS

Victor B. Scheffer, coauthor of the previous two editions, reviewed the entire manuscript. P. J. H. van Bree and C. A. Repenning reviewed in detail the sections on cetaceans and pinnipeds, respectively. P. B. Best, W. F. Perrin, and P. D. Shaughnessy provided valuable comments on portions of the manuscript.

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NOAA Technical Report NMFS SSRF-712

Annual Physical and Chemical Oceanographic Cycles of Auke Bay, Southeastern Alaska

Herbert E. Bruce, Douglas R. McLain,
and Bruce L. Wing

May 1977

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Annual Physical and Chemical Oceanographic Cycles of Auke Bay, Southeastern Alaska

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May 1977

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Annual Physical and Chemical Oceanographic Cycles of Auke Bay, Southeastern Alaska

HERBERT E. BRUCE, DOUGLAS R. McLAIN, and BRUCE L. WING[1]

ABSTRACT

The annual cycles of physical and chemical oceanographic conditions in Auke Bay, a small estuary in southeastern Alaska, showed a consistent pattern over an 8-yr period (1961-68). The cycles closely followed seasonal climatological and atmospheric events. Increased insolation in the spring caused general warming of the surface water and the air, which in turn increased the freshwater input into Auke Bay from melting snow and ice. The fresh water lowered surface salinities and together with warming of the surface waters caused a density stratification of the water column, which increased as the spring-summer season progressed. Maximum stratification occurred in August, followed by a general decay of stratification in September. Vertical mixing of the top 20 m of the water column by fall storms in September and cooling of surface water resulting from decreased insolation set up a thermohaline circulation that continued through the fall and early winter. The water column became homogeneous by January and remained thoroughly mixed from January through March or early April.

Auke Bay was rich in the inorganic nutrients phosphate, silicate, and nitrate. Spring phytoplankton blooms followed the onset of stratification and drastically reduced the concentration of all three nutrients in the surface water. Nitrate was essentially depleted and remained so throughout the summer. Low nitrate availability was undoubtedly one of the important factors limiting primary production in Auke Bay.

INTRODUCTION

Auke Bay is one of the many small bays along the major straits and passages of the inside waters of southeastern Alaska. Although these bays represent a small percentage of the total water mass of the area, they are important as spawning and nursery grounds for several species of fish and shellfish. Streams tributary to Auke Bay are spawning grounds for four species of salmon: pink, *Oncorhynchus gorbuscha*; chum, *O. keta*; coho, *O. kisutch*; and sockeye, *O. nerka*. Herring, *Clupea harengus pallasi*; king crabs, *Paralithodes camtschatica* and *P. platypus*; snow crab, *Chionoecetes bairdi*; and other species of commercial and recreational value spawn in the bay itself.

Several reports describe aspects of physical and chemical oceanography of small bays and estuaries in southeastern Alaska. Barnes et al. (1956) made an intensive survey (including some biological observations) of Silver Bay on Baranof Island near Sitka before construction of a pulp mill. Powers (1963) examined Little Port Walter at the southern end of Baranof Island. The U.S. Federal Water Pollution Control Administration (1966) made surveys of Gastineau Channel and Fritz Cove near Juneau and of Silver Bay and Ward Cove near Ketchikan in the summer of 1965. McLain (1968) surveyed Traitors Cove on Revillagigedo Island. McLain (1969) described seasonal changes in oceanographic conditions in Lynn Canal. Nebert and Matthews (1972) described the circulation of Endicott Arm. Most of these studies were less than 2-yr duration, not long enough to separate short-term and protracted hydrographic disturbances known to occur in natural environments.

Therefore, in our study of Auke Bay, the objective was to describe the annual cycles of oceanographic conditions in the bay over several years. In this way the complete annual cycle and the range of natural environmental variability could be identified. From this information the biological consequences of normal cycles and anomalous oceanographic conditions could be assessed.

DESCRIPTION OF STUDY AREA

Physiography and Geology

Auke Bay is one of a large number of small embayments off a system of large fiords connecting with the open ocean (Fig. 1). It is located at lat. 58°22′N and long. 134°40′W, 19.3 km northwest of Juneau, Alaska, and about 130 km inland from the open Gulf of Alaska. The bay covers an area of about 11 km^2 and contains several small islands and reefs.

The bottom topography of the bay is irregular, and submarine gulleys and mounts are quite common (Fig.

---

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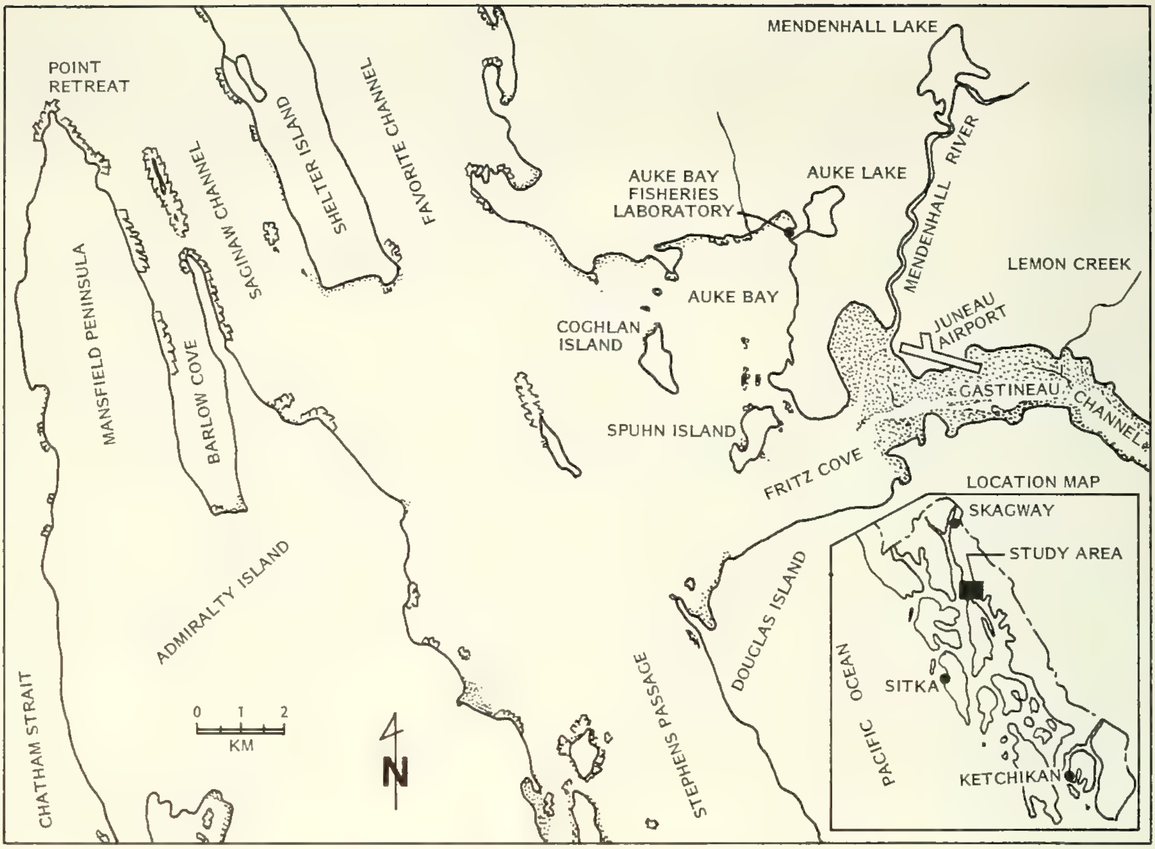

Figure 1.—Auke Bay, Alaska, and surrounding area.

2). The maximum depth, 100 m, is near the south end of Coghlan Island; depths of 40 to 60 m are common over much of the bay.

Auke Bay is not a fiord-type estuary of the form described by Pritchard (1952), but is a small tributary embayment to a system of large fiords. Lynn Canal-Icy Strait-Chatham Strait and Stephens Passage-Frederick Sound-Chatham Strait are major interconnected passages in southeastern Alaska and provide communication between Auke Bay and the Gulf of Alaska. The entire region was heavily glaciated during the Pleistocene Eopch. Martin and Williams (1924) concluded that glacial deepening of a preexisting river valley was the primary process in the formation of the Chatham Strait-Lynn Canal fiord. Auke Bay may have formed as a side valley of the larger fiord system.

Climatology

Auke Bay lies within that part of the maritime province extending along the northwest coast of North America. Winds in this area are predominantly southerly off the Pacific Ocean. These warm, moisture-laden winds strike the high coastal ranges and result in abundant precipitation, little sunshine, and moderate air temperatures. Observations by the National Weather Service at the Juneau Airport 3 km east of Auke Bay are that precipitation in the area is lightest in the spring and heaviest in the fall (Fig. 3). Between February and May the average monthly precipitation rate is fairly constant (the monthly average for 1931-60 was 6.6 cm). Precipitation increases rapidly in June and reaches a maximum in October (the 30-yr average for October 1931-60 was 21.3 cm).[2] After the October maximum, precipitation decreases until February.

The average monthly insolation for the Auke Bay area from 1959 to 1962 is shown in Figure 4. Insolation, which we estimated from cloud cover data, is a predominant factor in controlling seasonal cycles of air and sea surface temperature. Data from Roden (1959) on the total amount of radiation received at sea level under cloudless skies were converted to insolation under cloud cover according to the equation of Sverdrup et al. (1942):

$$Q_i = Q_0(1-0.071\ C)$$

where Q_i = radiation received at sea level adjusted for cloud cover
Q_0 = total incoming radiation under cloudless skies
C = amount of clouds (in tenths of sky covered).

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[2] The average was calculated from data in the U.S. Weather Bureau's annual publication Climatological Data, vols. 17-46, Alaska section (No. 13).

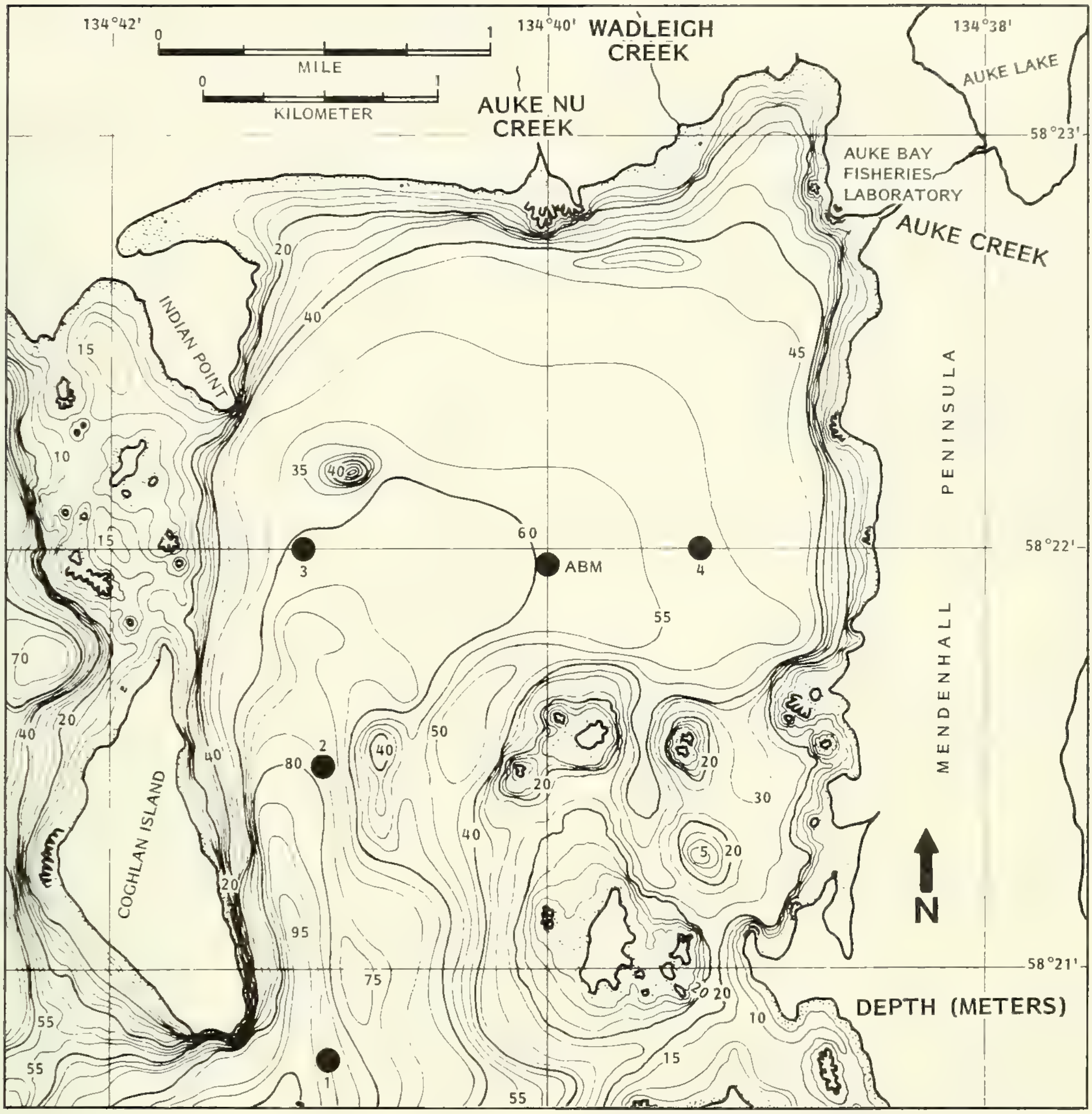

Figure 2.—Bathymetry of Auke Bay, Alaska, and locations of oceanographic stations.

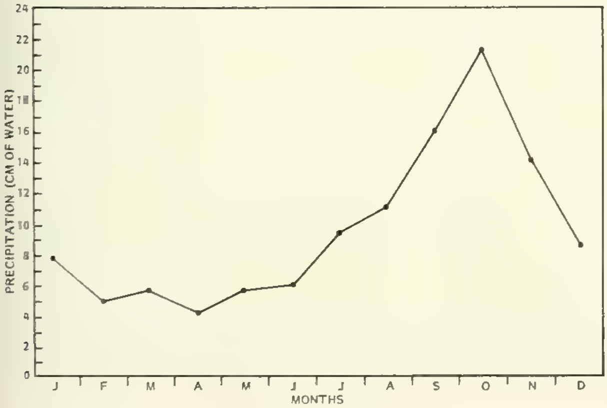

Figure 3.—Average monthly precipitation (cm of water) at Juneau airport, 1931-60. (See text footnote 2.)

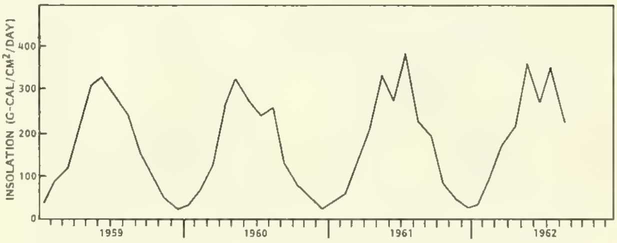

Figure 4.—Monthly averages of daily insolation (g-cal/cm²/day) in Auke Bay area, 1959-62. (See text for calculation of insolation.)

Runoff

The streams entering directly into Auke Bay are small and drain low-elevation (less than 900 m) forested areas. The streams are fed by rainfall and melting winter snows, and discharge from them has several maxima and minima each year that vary in timing from year to year. These are Auke Creek, Auke Nu Creek, Wadleigh Creek, and several smaller unnamed streams.

The larger more distant Mendenhall River and Lemon Creek discharge into Fritz Cove and Gastineau Channel adjacent to Auke Bay. Their waters eventually enter Auke Bay. The watersheds of these larger streams are rocky slopes, ice and snow fields, and glaciers. The monthly discharge follows an annual cycle, with a single minimum in February or March and a single maximum in July (U.S. Geological Survey 1964). The winter minimum is caused by a decreased rate of snowmelt at higher elevation and the summer maximum by a combination of increased snowmelt and moderate precipitation.

Tides

The tides in Auke Bay are semidiurnal and show diurnal inequality. The mean tidal range is slightly more than 4 m (U.S. Coast and Geodetic Survey 1962). Spring tides exceed this by almost 2 m. The times and heights of high and low water are nearly the same over the entire Auke Bay area.

PHYSICAL AND CHEMICAL OCEANOGRAPHIC FEATURES OF AUKE BAY

The Northwest and Alaska Fisheries Center Auke Bay Laboratory has collected descriptive physical and chemical oceanographic data in Auke Bay since 1959. These oceanographic observations have been parts of a variety of projects with differing needs and goals, so the schedules and types of observations have varied over the years. The seasonal cycles described in this report are derived primarily from data collected from 1961 to 1967, supplemented by some earlier and later observations.

Five oceanographic stations (Fig. 2) were occupied monthly during 1961-63. The local variations within the bay were relatively small when compared with the frequent transient vagaries. Oceanographic properties appeared to be homogeneously distributed over the area of the bay, and differences were usually within the limits of error in our measurements. Consequently, beginning in March 1963, the five stations were replaced with a single midbay station, Auke Bay Monitor (ABM, Fig. 2) which was monitored monthly for 1 yr. From March 1964 through July 1967, the ABM station was occupied approximately weekly in order to define more precisely short-term variations in oceanographic conditions associated with use of amino acids as a nitrogen source by the phytoplankton (Bruce 1969).

The observations were made with conventional Nansen bottles and reversing thermometers from the research vessels *Sablefish* and *Murre II* and from various small boats. The accuracy of the temperature measurements was estimated ±0.05°C. Salinities during the years 1959-64 were measured by titration, accurate to ±0.01°/₀₀ , and later by salinometer, accurate to ±0.05°/₀₀. Concentration of dissolved oxygen was measured by the conventional Winkler technique, accurate to ±0.1 ml/liter. Phosphates, nitrates, and silicates were determined by the methods of Strickland and Parsons (1960) and are believed within the precision limits of ±0.05, ±0.3, and ±3.0 μg-at./liter respectively.

Temperature

Water temperature is one of the most important characteristics of marine environments. The distribution of water temperature and salinity influences the physical mixing properties of the water. In addition, temperatures, along with salinities, are useful in identifying masses of water and in monitoring changes in physical and chemical properties of marine environments. Finally, temperature and temperature changes affect metabolism and other processes in marine plants and animals. Accordingly, this subject has been more fully investigated than any other physical factor.

The surface water temperature in Auke Bay ranged from less than 2° to 17°C; an extended minimum occurred between January and March and a maximum in August (Fig. 5). Sea surface temperatures were greater than the maximum air temperatures during the months of November to February, reflecting large heat losses to the atmosphere during the winter. Temperature variations were greatest at the surface and decreased with increasing depth (Fig. 6). At a depth of 50 m, the temperature ranged from 2° to 7.8°C. The month of maximum water temperature was progressively later in the summer at progressively greater depths. For example, the surface maximum was reached in August, and the maximum at 50 m was reached in October or November.

During the year vertical temperature profiles change from well mixed to strongly stratified (Fig. 7). In January

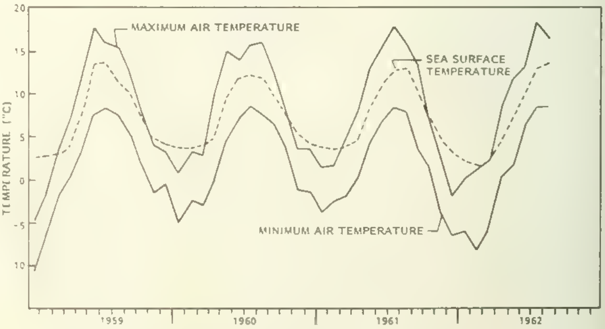

Figure 5.—Monthly averages of daily maximum and minimum air temperatures (°C) recorded at Juneau, Alaska, airport and of sea surface temperature (°C) at Auke Bay, Alaska, 1959-62.

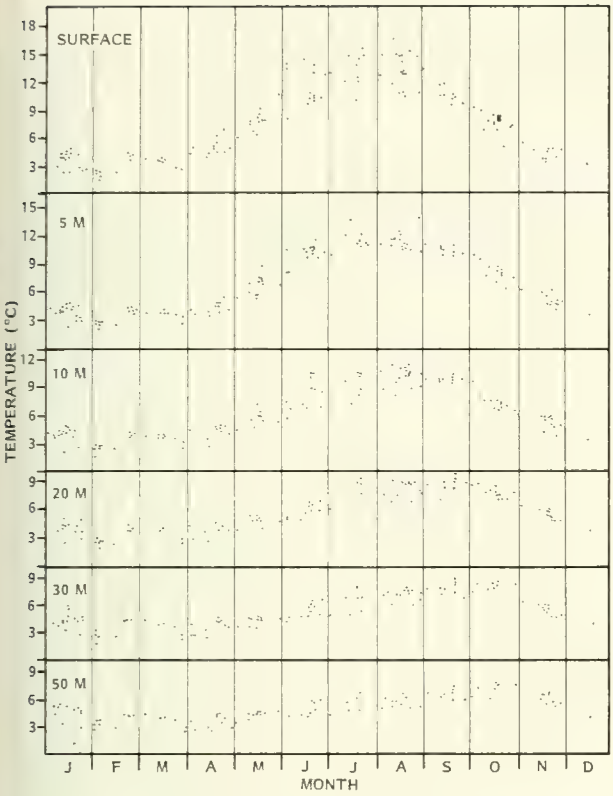

Figure 6.—Observed water temperatures (°C) at selected depths in Auke Bay, Alaska, 1960-68.

the water column is isothermal to a depth of 50 m. In April the surface waters begin to warm and start development of a thermocline. Between April and July, surface warming continues and by late July extends from 10 m. A lesser gradient in temperature exists from 10 to 30 m, and below 30 m the temperature changes very little. In the thermocline proper, a 10°C temperature difference may be encountered in July and August. After mid-September, the thermocline decays because of radiant heat losses and mixing by fall storms. The effect of storms is to change the distribution of heat, as illustrated by the decrease in the temperature of the surface waters to a depth of 10 m and a warming of the water below 10 m by vertical mixing. Between October and January, vertical mixing and cooling of the surface water continue, and in January conditions are again isothermal to a depth of 50 m.

Salinity

If we exclude those areas close to the outflow of large rivers or close to melting ice, the salinities of the world's oceans range from 32 to 38°/₀₀. The salinities of estuaries, however, are much more variable in time and space, ranging from near zero to more than 30°/₀₀. This wide variation is important as a selective agency in determining the composition and structure of biological communities.

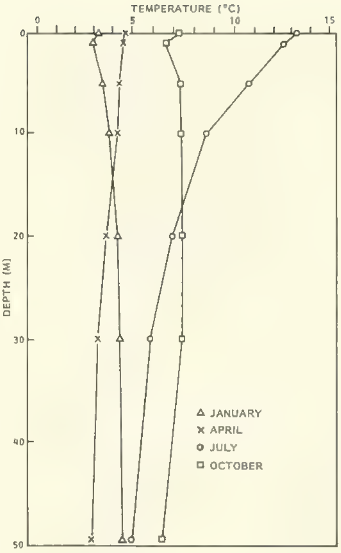

Figure 7.—Typical profiles of temperature (°C) in Auke Bay, Alaska, for January, April, July, and October; data are averages for 1960-68.

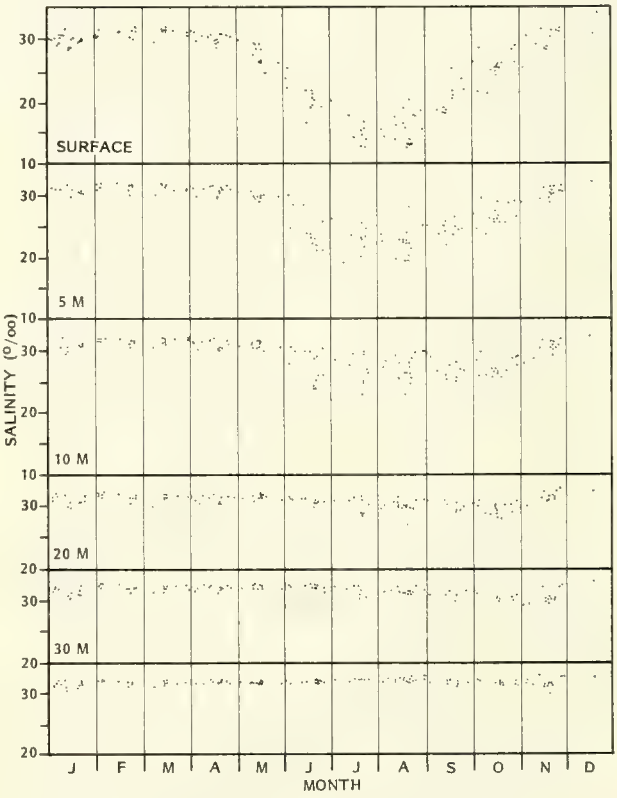

Figure 8.—Observed salinities (°/₀₀) at selected depths in Auke Bay, Alaska, 1960-68.

Variation of salinity at selected depths in Auke Bay from 1960 to 1968 is shown in Figure 8. In general, the annual cycle of salinity in the top 10 m was characterized by 1) a period from January to April when salinity remained between 29 and 31°/₀₀, 2) a period between May and July-August when salinity decreased to a minimum of about 17°/₀₀, and 3) a recovery period (September-December) when salinity increased again to the winter values. In deeper water (20 to 50 m) the salinity remained rather constant at 30 to 31 °/oo through the year. The salinity of surface waters varied 3 to 5 °/oo in a few days during the spring-fall period while short-term variations in the deeper water seldom exceeded 1 °/oo.

Two distinct layers of water—surface (to 30 m) and deep (below 30 m)—appear in the vertical profiles of salinity in Auke Bay (Fig. 9). Between January and April, isohaline conditions exist from the surface to 50 m. The salinity of the surface layer decreases continuously from April through July or August, and a strong salinity gradient forms in the top 10 to 12 m. The strongest halocline occurs in July with salinities near 20 °/oo at 5 m, 27 °/oo at 10 m, and 31 °/oo at 30 m. Surface salinity remains low through September and increases in October as a result of autumn storm mixing. The strong halocline of July and August is the result of peak runoff from the large, glacial-fed streams. Runoff from the low elevation, forested watersheds does not affect surface salinities as much as runoff from the glacial streams. Runoff from lower elevations peaks in both the spring and the fall, but not during the summer (McLain 1969). Often in the summer silty glacial Mendenhall River water intrudes from neighboring Fritz Cove into the clearer waters of Auke Bay.

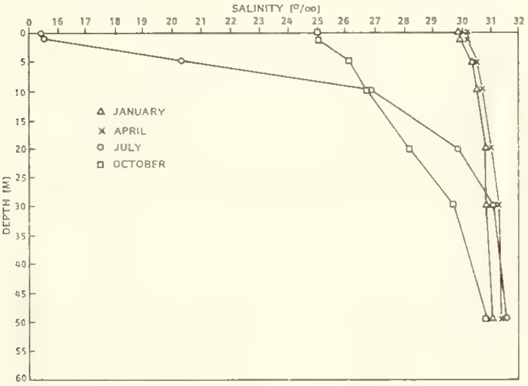

Figure 9.—Typical profiles of salinity (°/oo) in Auke Bay, Alaska, for January, April, July, and October; data are averages for 1960-68.

Density

Water density, a function of temperature and salinity, is used to identify water masses and to assess the stability or stratification and probable circulation of these water masses. Over the range of values observed in Auke Bay density is affected more by salinity variation than by temperature variation.

The annual cycle of water density of Auke Bay from 1960 to 1968 expressed in terms of σ_t[3] is shown in Figure 10. The density of the surface water in Auke Bay varied over a range of σ_t values between 9 and 24. Density was greatest and varied little with depth from December to April. In late April, density began to decrease at the surface and continued to decrease through July, reaching a minimum in August (mean minimum σ_t = 11.0). The change in σ_t occurred progressively later with increasing depths (Fig. 10). The minimum σ_t at 30 m was 22.2 in October. At 50 m the density was relatively constant and had no obvious maximum or minimum.

Figure 11 shows the seasonal vertical profiles of average σ_t. From January to April the water in Auke Bay is well mixed and the density is uniform from the surface to 50 m. From July to October there is a strong den-

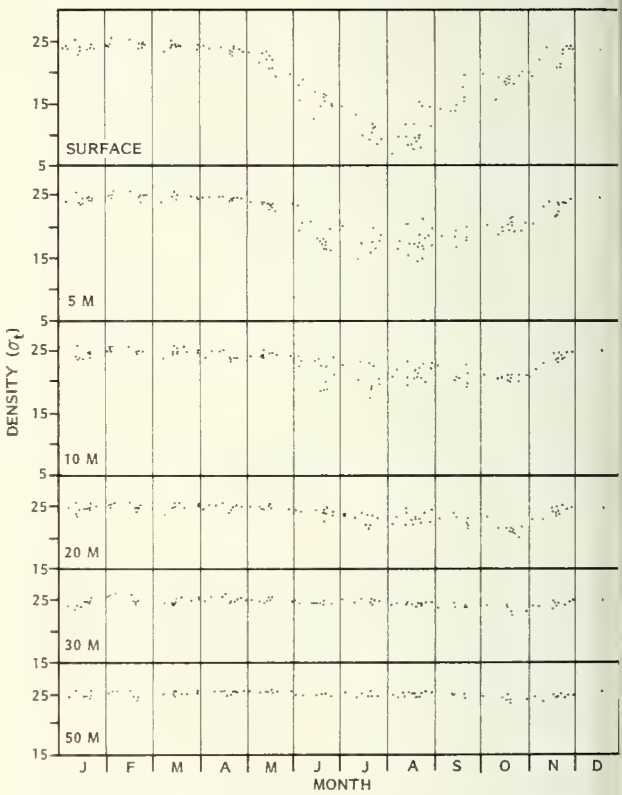

Figure 10.—Observed densities (as σ_t) at selected depths in Auke Bay, Alaska, 1960-68.

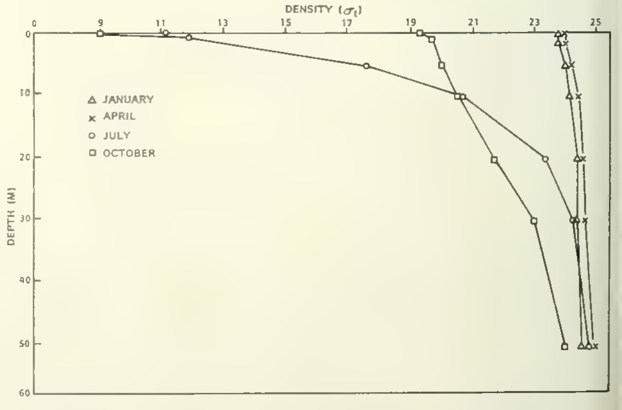

Figure 11.—Typical profiles of density (as σ_t) in Auke Bay, Alaska, for January, April, July, and October; data are averages for 1960-68.

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[3] Sigma-t (σ_t) = 1,000 (ρ-1) where ρ is the density of the water.

sity gradient from the surface down to 30 m. The data for all years of this study show the same seasonal pattern of density distribution.

Stability

Stability of a water column[4] is determined by the rate of change of density with depth, the vertical gradient of density. Where stability is high, vertical movement and vertical mixing are inhibited. The water column in a strong vertical gradient of density (a marked pycnocline) is very stable, and much more energy is required to displace particles of water upward or downward than in a region where the gradient is weak. This mechanism greatly restricts the vertical transfer of water from the deep layer to the upper layer in Auke Bay. Tidal-induced turbulence is unable to penetrate the pycnocline.

Table 1 gives numerical values for the stability of Auke Bay water during July and August 1965. All the stability values in Table 1 are positive and relatively high, indicating a highly stable water column. Data from other years show the same general density distribution as in 1965; all depict a highly stable water column during the summer. The similarity between seasonal cycles of salinity and density in Auke Bay (Figs. 8 and 10) is expected because of the strong dependency of density on salinity at the relatively low temperatures common in Auke Bay.

The development of a stable water column is one of the most ecologically significant features of the oceanography of Auke Bay because stability of the water column is a prerequisite for the onset of spring phytoplankton bloom (Riley 1942; Sverdrup 1953; Steele 1966). Gilmartin (1964) found that seasonal variability in the stability of the water column in a British Columbia fiord was the primary factor controlling phytoplankton growth. We observed a strong burst of phytoplankton growth each year in April or early May as solar radiation increased and a stable water column began to form. It is clear that stratification has a pronounced effect on the basic productivity of Auke Bay throughout the spring-summer growing season.

Dissolved Oxygen

Oxygen is one of the common gases dissolved in natural waters and is critically important because of its key role in biological energy transfers. Although aquatic organisms respire efficiently at oxygen concentrations considerably below saturation values, metabolic rates and efficiencies are dependent on the availability of dissolved oxygen. Consequently, the dissolved oxygen concentration is a major determinant of the environmental quality of water. The oxygen requirement of organisms is given generally in terms of absolute concentration expressed in appropriate units such as ml/liter or mg/liter.

Concentrations of dissolved oxygen at selected depths in Auke Bay are shown in Figure 12. Dissolved oxygen in the upper 5 m generally remained above 6 ml/liter, and spring and summer concentrations were above 8 ml/liter. Highest concentrations occurred from April through June and maximum observed value was 11.4 ml/liter. Below 10 m the concentration of dissolved oxygen decreased with depth. In winter the concentrations varied less with depths. The lowest concentrations of oxygen at or near the bottom occurred in September and October.

The degree of oxygen saturation provides information on the relative intensities of processes which affect the oxygen content of the water. Supersaturation is observed frequently and is essentially a result of high photosynthetic activity by plants in the upper layer of the water. Under conditions of high solar radiation during the day and abundant nutrients, the rate of oxygen production may exceed the rate at which oxygen is given

Table 1.—Stability (E)[1] at Auke Bay monitor station in July and August 1965.

	21 July 1965				10 August 1965			
Depth (m)	Temp. (°C)	Salinity (°/₀₀)	σ_t	10^6E	Temp. (°C)	Salinity (°/₀₀)	σ_t	10^6E
0	13.48	16.30	11.94		16.55	16.30	11.37	
				1,107				1,189
10	7.84	29.50	23.01		7.98	29.85	23.26	
				151				101
20	5.82	31.10	24.52		6.21	30.85	24.27	
				49				43
30	4.76	31.57	25.01		5.66	31.30	24.70	
				16				22
50	4.28	31.90	25.32		4.70	31.72	25.13	

[1] See text footnote 4.

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[4] For depths to 100 m, stability (E) can be expressed by

$$E = 10^{-3} \frac{d\sigma_t}{dZ} \text{ (Sverdrup et al. 1942, p. 417),}$$

or in different form

$$E = 10^{-3} \frac{(\sigma_{t_2} - \sigma_{t_1})}{(Z_2 \quad Z_1)}$$

where Z = depth
$dZ \cong Z_2 - Z_1$ = change in depth
$d\sigma_t \cong (\sigma_{t_2} - \sigma_{t_1})$ = change in σ_t
σ_t = 1,000 (ρ - 1) where ρ = density of the water.

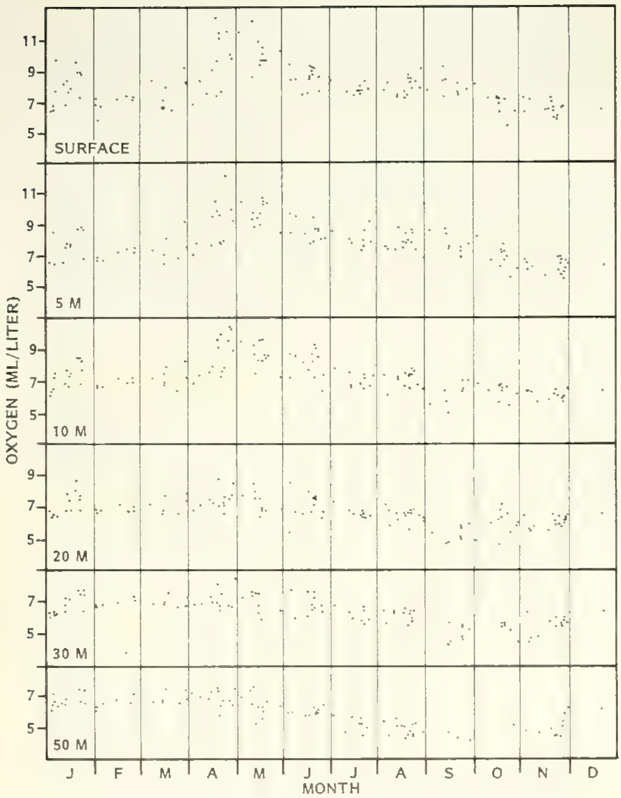

Figure 12.—Observed concentrations of dissolved oxygen (ml/liter) at selected depths in Auke Bay, Alaska, 1960-68; data are observed concentrations.

off at the surface, and supersaturation will occur. Appreciable supersaturation occurs in Auke Bay during the spring and summer, even down to 10 to 20 m (Fig. 13). This coincides with spring and summer phytoplankton blooms. Lowest concentrations of oxygen occur during the fall and winter when photosynthetic activity is reduced and bacterial decomposition and chemical oxidation of detritus lower the oxygen content.

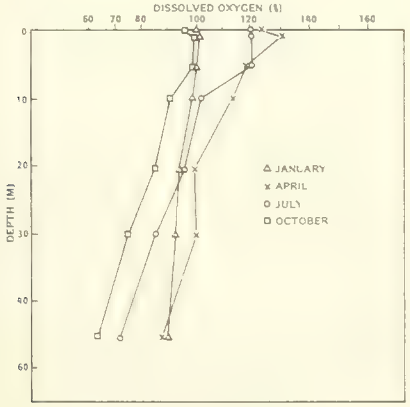

Figure 13.—Typical vertical profiles of percent saturation of dissolved oxygen in Auke Bay, Alaska, for January, April, July, and October; data are averages for 1960-68.

Inorganic Nutrients

The circulation of biologically active materials such as phosphate, silicate, and nitrate, as well as their distribution in the water column, depends on biological and physical processes and differs in detail from the circulation and distribution of water and its conservative properties. Because these materials are dissolved components of water, they are affected by advective and eddy diffusion processes. In addition, they are exchanged between the water and the biomass in a cyclic process. During periods of high biological activity, changes in the distribution and abundance of biologically active components of the water column may occur rapidly relative to changes due to physical processes alone. Thus, their study may add significantly to the physical description of an area.

During our study in Auke Bay, there was a regular seasonal cycle in concentrations of inorganic phosphate, silicate, and nitrate (Figs. 14, 15, 16). Maximum concentrations of all three nutrients occurred in winter (January-April), and all were uniformly distributed throughout the water column in this period. A rapid reduction of the three nutrients above 20 m in April was associated with the outburst of phytoplankton growth. In each year of our study, we noticed a marked rise in numbers of diatoms and chlorophyll concentrations and a corresponding drop in concentrations of phosphate, silicate, and nitrate (unpublished data on file Northwest and Alaska Fisheries Center Auke Bay Laboratory). Once stability is established in spring, high levels of photosynthetic activity rapidly deplete the available nutrients because vertical advection of nutrients into the surface is inhibited by the stability of the water column.

Raymont (1963) reviewed the distribution and amounts of phosphate, silicate, and nitrogen throughout the world oceans, including many of the important coastal and inshore areas. In comparison with other nutrient-rich coastal and inshore environments, the amounts of these materials in Auke Bay water were relatively high. Friday Harbor in western Washington had some of the highest observed concentrations of both phosphate and nitrate—about 1.8 μg-at./liter of phosphate and 21.0 μg-at./liter of nitrate (Raymont 1963). Riley and Conover (1956) found maximum phosphate and nitrate concentrations in Long Island Sound of 1.9 and 17.0 μg-at./liter, respectively. Maximum concentrations in Auke Bay were 3.5 μg-at./liter of phosphate and 26.0 μg-at./liter of nitrate. Maximum silicate concentrations in Auke Bay were also comparatively high—70.0 μg-at./liter. This is significantly greater than the maximum values reported for the English Channel, 5.0 μg-at./liter, or for Friday Harbor, 53 μg-at./liter (Raymont 1963). The highest silicate concentration reported anywhere was 160 μg-at./liter in the deep water of the North Pacific Ocean (Raymont 1963).

In general, throughout the summer, phosphate values in Auke Bay in the upper 5 m tended to remain low, although there were some fluctuations. Minimum concentrations of phosphate observed in surface water were

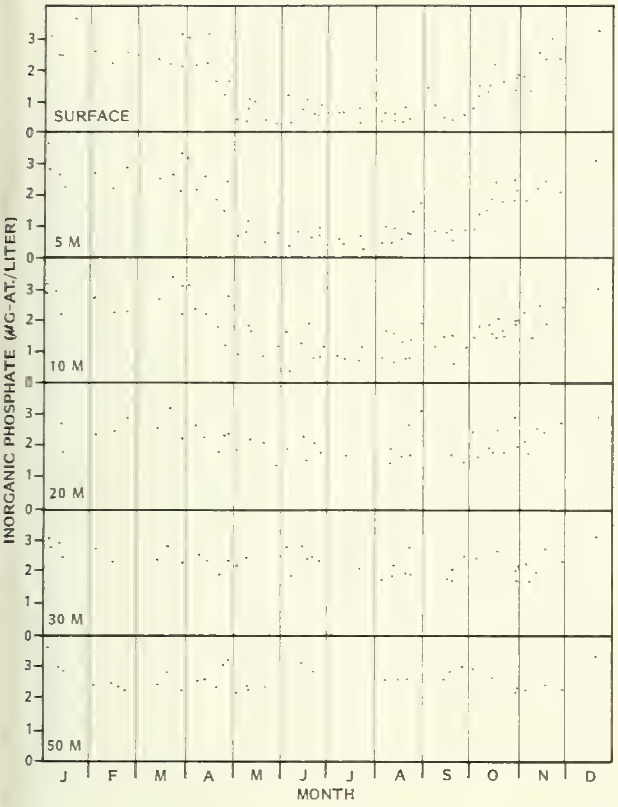

Figure 14.—Observed concentrations of inorganic phosphate (µg-at./liter) at selected depths in Auke Bay, Alaska, 1963-67.

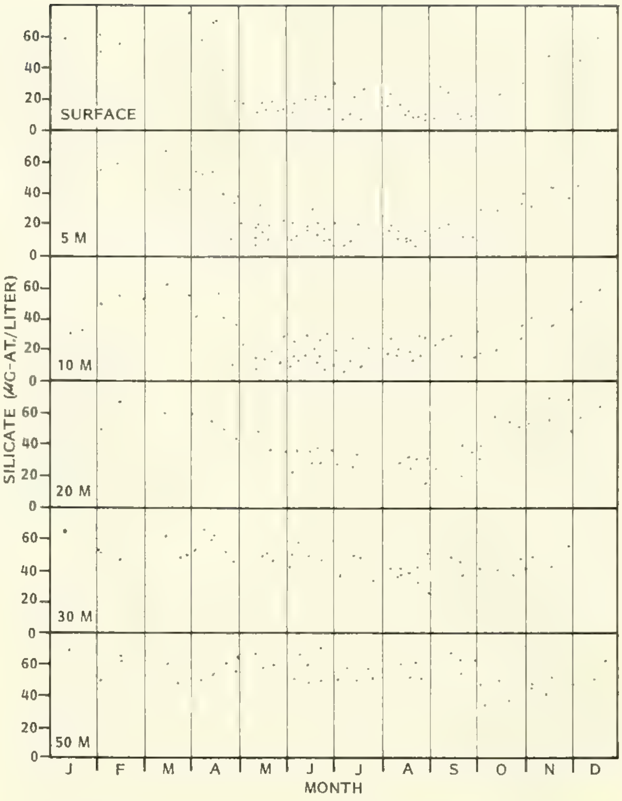

Figure 15.—Observed concentrations of dissolved silicate (µg-at./liter) at selected depths in Auke Bay, Alaska, 1963-67.

between 0.30 and 0.20 µg-at./liter, versus a winter high of 3.0 to 3.5 µg-at./liter (Fig. 14).

Short-term increases in phosphate concentrations in the top 5 m from May through August did not have a strong coincidence with periods of increased runoff. Hence, freshwater input was discounted as a significant cause of increases in nutrients, including phosphate, over short time periods (3 to 7 days). Studies by Curl, Iverson, and Conners[5] showed that tidal effects in Auke Bay were not sufficient to mix nutrient-rich water into the euphotic zone, but that wind-induced mixing through the pycnocline could be caused by winds of 4 m/s persisting for 24 h or longer.

Although the causes of fluctuation in phosphate levels are not clear, the most probable causes are regeneration of inorganic phosphate from organically bound phosphate and wind-induced vertical mixing of inorganic phosphate through the pycnocline. Laboratory measurements of the rate of phosphate regeneration (Cooper 1935) indicate that up to one-half of the total phosphorous content of decomposing plankton appears in soluble form within 24 h.

The silicate cycle in Auke Bay (Fig. 15) generally paralleled the phosphate cycle; this similarity was also demonstrated by Richards (1958) in the western Atlantic. Studies in the English Channel by Atkins (1930) showed that silicate was depleted and regenerated simultaneously with phosphate.

While phosphate and silicate in Auke Bay had the same general seasonal patterns of distribution, some differences appear when the data are examined in detail: short-term variation in concentration of phosphate occurred primarily in the upper 5 m of the water column (Fig. 14); the greatest variations in silicate occurred between 10 and 20 m (Fig. 15). Variability in the concentration of silicate throughout the water column in Auke Bay is generally greater than it is for phosphate.

Minimum silicate concentrations of 2 to 4 µg-at./liter occurred in the surface water of Auke Bay during July, August, and September (Fig. 15). Short-term increases occurred in late June and early July, when the proportion of dinoflagellates (phytoplankton which do not utilize silicate) to diatoms was quite high. We interpreted this increase as a reflection of the difference in rate of uptake by the relatively small number of diatoms present and the rate of in situ regeneration, plus advective input.

Maximum silicate concentration of about 60 µg-at./liter occurred throughout the water column from December through the middle of March—a high concentration even for inshore waters. Offshore waters usually contain an order of magnitude less silica, although the level is quite variable.

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[5] Curl, H. C., Jr., R. L. Iverson, and H. B. O'Conners, Jr. 1971. Pelagic ecology of biological production in Auke Bay, Alaska. Final report to National Marine Fisheries Service, Auke Bay Fisheries Laboratory, Auke Bay, Alaska, Contract 14-17-0005-207.

The nitrate cycle in Auke Bay paralleled in general the phosphate and silicate cycles. Maximum concentrations of 24 to 28 μg-at./liter were present throughout the water column during the winter period (Fig. 16). The reduction of nitrate in the top 5 m from 24-28 μg-at./liter to 0.5 μg-at./liter with the outburst of phytoplankton growth in April is more drastic than in phosphate and silicate.

The short-term fluctuations that occurred in concentrations of phosphate and silicate did not occur in nitrate concentrations. The top 5 m were essentially depleted of nitrate by May and remained impoverished through August. We attribute this to a slow regeneration rate of nitrate from organic combinations, which according to the experiments by Brand and Rakestraw (1941) requires 3 or 4 mo. Riley (1967) presented indirect evidence that the nitrogen cycle is significantly slower than the phosphate cycle.

The summer pycnocline is enough of a barrier to prevent nitrate from reaching the surface in any significant quantity (this is true also for phosphate and silicate), except during periods when wind velocity is at least 4 m/s for at least 24 h. Periodic measurements of the nitrate content of fresh water entering Auke Bay show that only negligible amounts of nitrate enter the bay from these sources.[6]

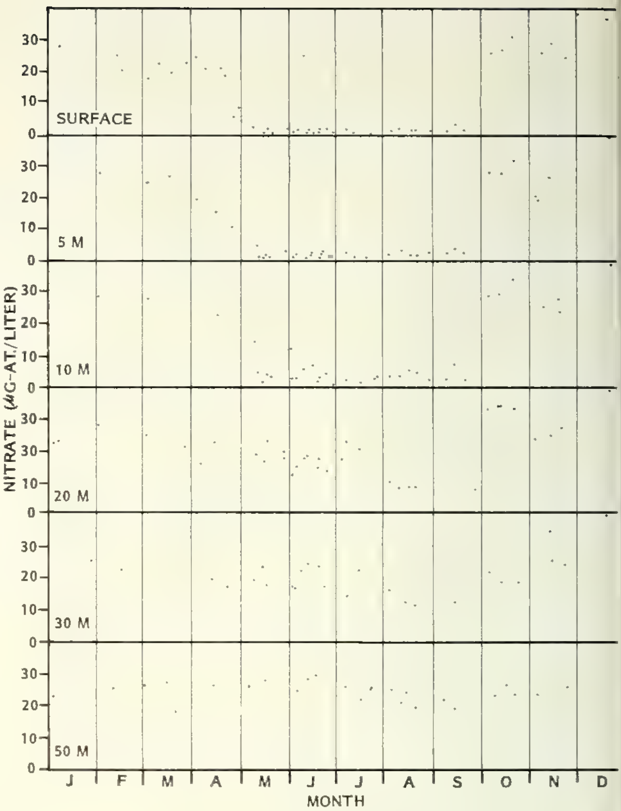

Figure 16.—Observed concentrations of dissolved nitrate (μg-at./liter) at selected depths in Auke Bay, Alaska, 1963-67.

SUMMARY

This study has described temporal variation in oceanographic conditions over an 8-yr period and provides background information on environmental variability for future detailed studies of the ecology of Auke Bay. Salient environmental features of an annual cycle in Auke Bay are summarized below.

Auke Bay is about 130 km from the open ocean and is relatively isolated from direct oceanic moderation and from major circulation patterns of the main passages and straits in southeastern Alaska. The bay is strongly influenced by land runoff and by the local climate. The annual oceanographic cycles closely follow local atmospheric cycles.

By the end of the second week in April, the water column began to stratify because of increased absorption of solar radiation in the upper 5 m and the accumulation of fresh water on the surface from increased runoff and precipitation. As the spring-summer season progressed, stratification increased until a strongly developed pycnocline essentially isolated the upper 12 to 20 m from the deeper water.

Full development of the brackish surface layer in Auke Bay occurred in late July or August. In September, cooling of surface water coupled with wind mixing due to fall storms broke the density stratification developed during the spring-summer period. Nutrient-rich water below the pycnocline was mixed into the euphotic zone to replenish the nutrient-impoverished surface water, and a fall phytoplankton bloom occurred.

As the season progressed into fall, decreasing temperatures and increasing salinities in the surface layer of water increased the density of the surface water, resulting in thermohaline circulation which thoroughly mixed the water column. Hence, during the winter, the water column was essentially homogeneous, and the concentrations of phosphate, silicate, and nitrate throughout the water column were high. A well-mixed water column and low solar radiation prevented any significant phytoplankton growth during the winter; consequently, the distribution of biologically active dissolved components depended almost totally on physical processes during the winter.

The seasonal pattern described was repeated each year during the 8-yr period that routine observations were made.

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[6] Unpublished data on file Northwest and Alaska Fisheries Center Auke Bay Laboratory, NMFS, NOAA, P.O. Box 155, Auke Bay, AK 99821.

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Richard R. Straty

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Current Patterns and Distribution of River Waters in Inner Bristol Bay, Alaska[1]

RICHARD R. STRATY[2]

ABSTRACT

Hydrographic studies to determine the distribution of the waters of the major sockeye-salmon-producing river systems in inner Bristol Bay show the net seaward flow of river water is along the northwest (right) side of inner Bristol Bay. The net motion of seawater toward the head of Bristol Bay transports with it the waters of Ugashik and Egegik rivers, which enter the bay on the southeast side. Near Egegik Bay to Middle Bluff, the mixed sea and river waters join the seaward flow of Kvichak and Naknek river waters, which enter at the head of Bristol Bay. Waters of these four rivers, along with the large volume of water from the rivers entering Nushagak Bay, are eventually transported to, and move seaward on, the northwest side of Bristol Bay. Waters of Naknek, Egegik, and Ugashik rivers are similar to each other in the courses followed during ebb and flood tides. Flood tide currents, along with the nontidal current, transport water from Egegik and Ugashik rivers above or north of the entrance to Egegik and Ugashik bays.

INTRODUCTION

The distribution and migratory behavior of juvenile and adult sockeye salmon, *Oncorhynchus nerka*, while in Bristol Bay are influenced by physical and chemical properties of the bay. The literature on salmon behavior indicates that certain features of a bay or estuary, such as salinity gradients (McInerney 1964), or physicochemical properties of home-river waters (Hasler and Wisby 1951; Wisby and Hasler 1954; Donaldson and Allen 1958; Hara et al. 1965; Hasler 1966), may provide directive cues to salmon during their seaward and homing migrations. In Bristol Bay, the distribution of home-river waters and the physicochemical properties they contain are the result of ocean currents.

In conjunction with investigations by the National Marine Fisheries Service of the early marine life of sockeye salmon (Straty 1974) and their later distribution during spawning migration (Straty 1975), data were collected to describe the current patterns and distribution of waters from the major sockeye-salmon-producing river systems in Bristol Bay. Such information was expected to provide a better understanding of the relationship between environmental factors and behavior of salmon while in Bristol Bay and to provide knowledge for predicting the distribution of pollutants which might be introduced into the bay or rivers during the critical period when salmon are present.

In this paper I describe the distribution of water from each major river system as it flows out of the bay and describe current patterns of the mixed sea and river waters within the bay.

BACKGROUND

Bristol Bay, the southeastern terminus of the shallow continental shelf of the Bering Sea, is considered to be the area east of a line drawn from Cape Sarichef on Unimak Island to the Kuskokwim River (Fig. 1). Unimak Island and the Alaska Peninsula bound Bristol Bay on the south and east and separate it from the North Pacific Ocean. The studies reported here were conducted in the inner bay between Kvichak and Cinder rivers (Fig. 1).

Most of the precipitation in Bristol Bay occurs from July through September. Total rainfall varies from 76.2 to 101.6 cm annually, August being the rainiest month (U.S. Coast and Geodetic Survey 1964). Mean air temperature is about 1.7°C. Fog occurs in every month of the year at most localities. Ice begins to form along shores of the bay in October or November and expands seaward until March. Although the ice pack usually begins to break up and melt in April, compact fields of drift ice may remain offshore until late May. Over much of Bristol Bay, winds are from the northeast from October to March and from the southeast in spring, summer, and early fall. Average wind velocity is 15 knots at Port Heiden in outer Bristol Bay and about 10 knots at Naknek at the head of the bay.

Movement of water in Bristol Bay is affected by ice, runoff, winds, tidal currents, density gradients, and movement of oceanic water off the continental shelf. The funnel-shaped configurations of the bay and of the river entrances create tidal currents with velocities up to 6 knots. Tides and currents in the bay are the mixed type in which two highs and two lows occur during a tidal day, generally with a significant diurnal inequality. The diurnal range of tide averages about 5.5 m at river entrances.

---

[1] Based in part on a thesis submitted to the graduate school of Oregon State University, Corvallis, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June 1969.

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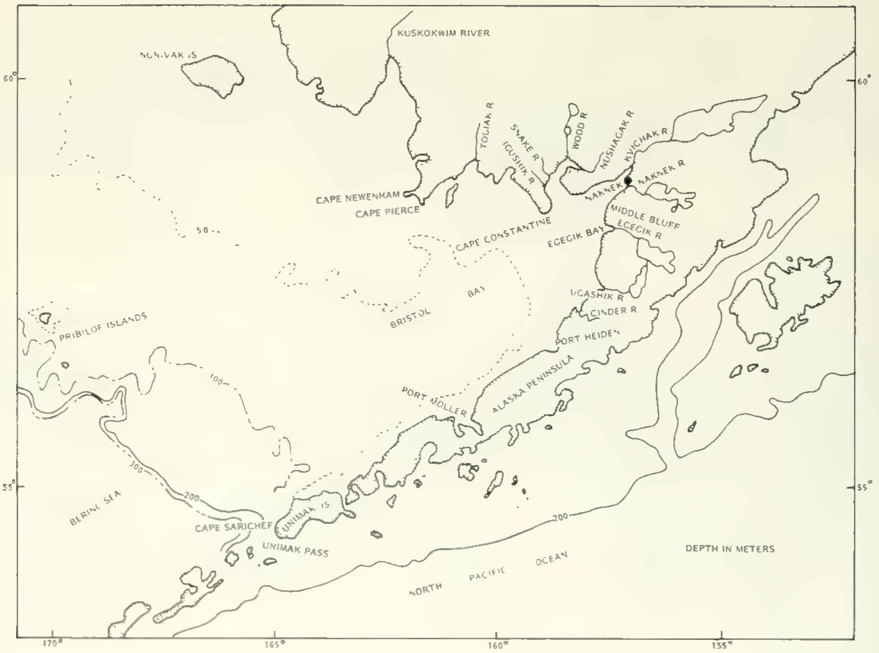

Figure 1.—Bristol Bay, showing locations of principal river systems.

Dodimead et al. (1963) depicted the pattern of the nontidal currents in a review of the general oceanographic conditions in Bristol Bay from May through August in 1938 and 1939. Dodimead et al. (1963) inferred from salinity and sigma-*t* distributions that water in the bay moved counterclockwise. Hebard (1959) determined that the average velocity of this current near Port Moller (Fig. 1) on the Alaska Peninsula was slightly less than 0.1 knot, or about 2 n.mi./day.

In spring (May and June) a temperature front occurs in the seawater across the bay and separates waters of the inner bay from those of the outer bay. In 1939 this front occurred along a line from Port Heiden to Cape Pierce; surface temperatures and salinities indicated the presence of counterclockwise gyres both shoreward and seaward of this front (Dodimead et al. 1963). The inshore gyre was apparently confined to the surface, and warm dilute river runoff was contained eastward of Cape Pierce and forced to recirculate shoreward of this front. By August the temperature front had disappeared, and a peripheral counterclockwise flow was evident throughout the bay.[3] These descriptions of water movement apply to the area seaward of a line between Cape Constantine and Egegik Bay (Fig. 1).

DISTRIBUTION OF RIVER WATERS

Three methods were used to determine the distribution of waters from individual river systems in inner Bristol Bay: 1) measuring vertical and horizontal distributions of salinity, 2) tracking river waters tagged with a fluorescent dye, and 3) tracking drift cards released at strategic locations in the bay.

Four Bristol Bay river systems were studied—Naknek, Kvichak, Egegik, and Ugashik (Fig. 1). These systems were chosen because their average combined production of sockeye salmon is more than 70% of the total annual Bristol Bay run. Moreover, a considerable amount of inshore mark-and-recovery data were available for adult salmon of stocks occurring along the southeast side of the inner bay where these rivers enter.

Determining Salinity Distribution

Salinity was measured in 1966 at stations along six parallel transect lines across inner Bristol Bay. The stations were located at 8-km intervals along the offshore transect lines, which were 16 km apart, and at 1.6- and 3.2-km intervals along inshore transect lines, which were 8 km apart. Salinity was measured with a Beckman Model RS5-3 electrodeless induction salinometer at the surface and at 1- and 2-m intervals thereafter to the bottom at low tide and usually during the following high tide.

Data were collected on consecutive days in late July and August during periods when tidal conditions were as nearly similar as possible. Although transects could not always be run on the desired tide because of inclement weather and darkness, they could usually be run on the lowest and highest tides of the day. Coverage of a transect line usually began between 1 and 1½ h before low or high tide. The tracking vessel was kept on a constant compass course along a given transect line as it traveled between stations so that it moved toward the head of the bay or seaward at a rate controlled by the speed of the tidal current. In this way the vessel was assumed to remain in water representative of water at the beginning of a transect run.

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[3] Recent data collected by the National Marine Fisheries Service, which are on file at the Auke Bay Laboratory, Auke Bay, Alaska, suggest that a temperature front occurs annually, but its location may vary from year to year.

Transects were usually run when the wind velocity was 10 to 15 knots; speeds greater than 13 knots caused waves to become unstable and break into whitecaps, resulting in an increase in the mixing of the surface waters (Johnson 1960).

The vertical and horizontal profiles of salinity in inner Bristol Bay are used to interpret distribution of river waters in the inner bay where there is very little vertical variation in salinity (Fig. 2). Vertical mixing is caused by the high velocities of the tidal current, shallow depth, and wind. Salinity in inner Bristol Bay varied horizontally, as shown by surface and bottom salinities at low and high tides (Figs. 3-6); salinity was low on the northwest side and high on the east side. Dodimead et al. (1963) found that this condition persisted farther offshore: low-salinity water moved seaward on the northwest side of the bay, and a countercurrent of high-salinity water was present on the southeast side. This current appeared as a wedge of high-salinity water between the river waters entering each side of the bay.

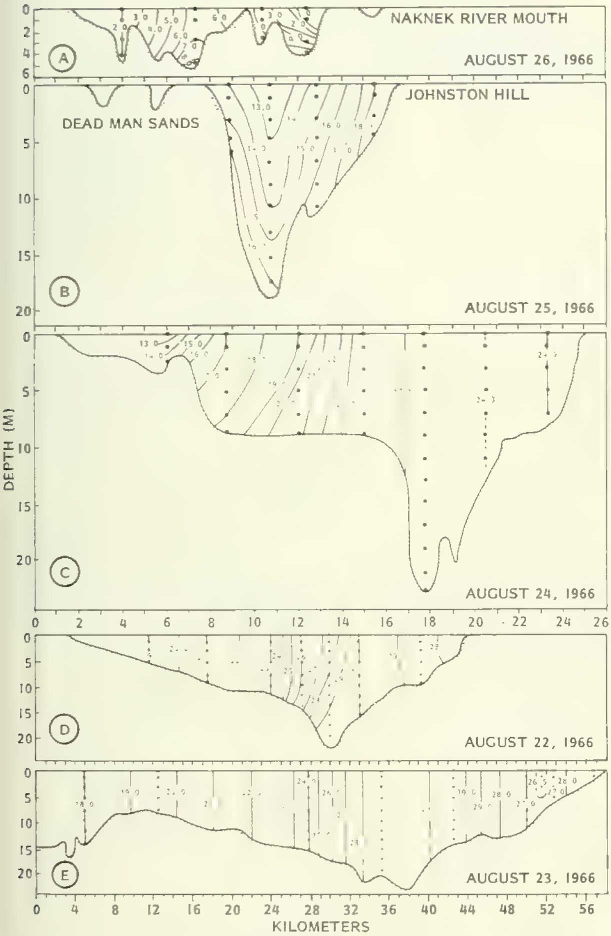

Figure 2.—Vertical profiles of salinity (‰) at 16-km intervals across inner Bristol Bay, August 1966.

Dye Studies

To track water from individual rivers, I used a tracer technique utilizing a fluorescent organic pigment, Rhodamine B (alkyl aminophenol derivative).[4] This technique was first used by Pritchard and Carpenter (1960) to observe the movement and dispersion of water in various parts of Chesapeake Bay.

Ideally, a tracer is released into a river when a continuous flow is expected for a period of time long enough for the tracer to achieve equilibrium with its environment. However, the objectives of my study could be met by instantaneous release of enough Rhodamine B to trace its course over one or two tidal cycles. The dye was released only on days when wind velocities were less than 15 knots because the wind is considered to be an important agent of mixing and dispersion of a tracer in short-term studies such as mine. The dye was rapidly poured from plastic containers into the propeller wash of the tracking vessel while traveling at a speed of 5 knots. Approximately 9.5 to 18.9 liters of dye were released about 1 h after high slack tide along a continuous line 3 m wide across the main channel of the river. The channel was crossed three or four times with a line of dye laid down about 15 m upstream from the previous line. The dye mixed rapidly with the water to a depth of 2 m; within 1 h after release it had mixed to a depth of 4 m. Usually within 1 h, individual lines of dye had diffused horizontally and merged with one another, producing a visible patch across the channel 60 m or more wide. Dye was also released in a similar manner near the end of the ebb tide offshore across the course assumed by the dye previously released at the beginning of the ebb tide. The course of this release was followed during the following flood tide.

Paths of Fluorescent Dye.—Dye was released into Naknek, Egegik, and Ugashik rivers in July and August 1965 and 1966. No dye was released in the Kvichak River because the course and distribution of Kvichak River water in inner Bristol Bay could be logically deduced from results of the Naknek River study and the surveys to measure salinity. The tracks of 11 dye releases in the three rivers showed that river waters followed rather discrete and similar courses in the inner bay (Figs. 7, 8). The course of dye released near the end of ebb tide at the mouths of the three rivers indicated that a portion of the river water was carried north by the succeeding flood tide (Fig. 8). Water entering the bay from these rivers (and Kvichak River) near the end of ebb tide constitutes the greatest fraction of river water entering the bay during a tidal cycle. In most cases, dye was tracked on the flood

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[4] Rhodamine B dye was purchased as a 40% (by weight) acetic acid solution. Because the density of the solution was greater than that of the water into which it was to be released, its specific gravity was adjusted to 1.00 by the addition of methyl alcohol.

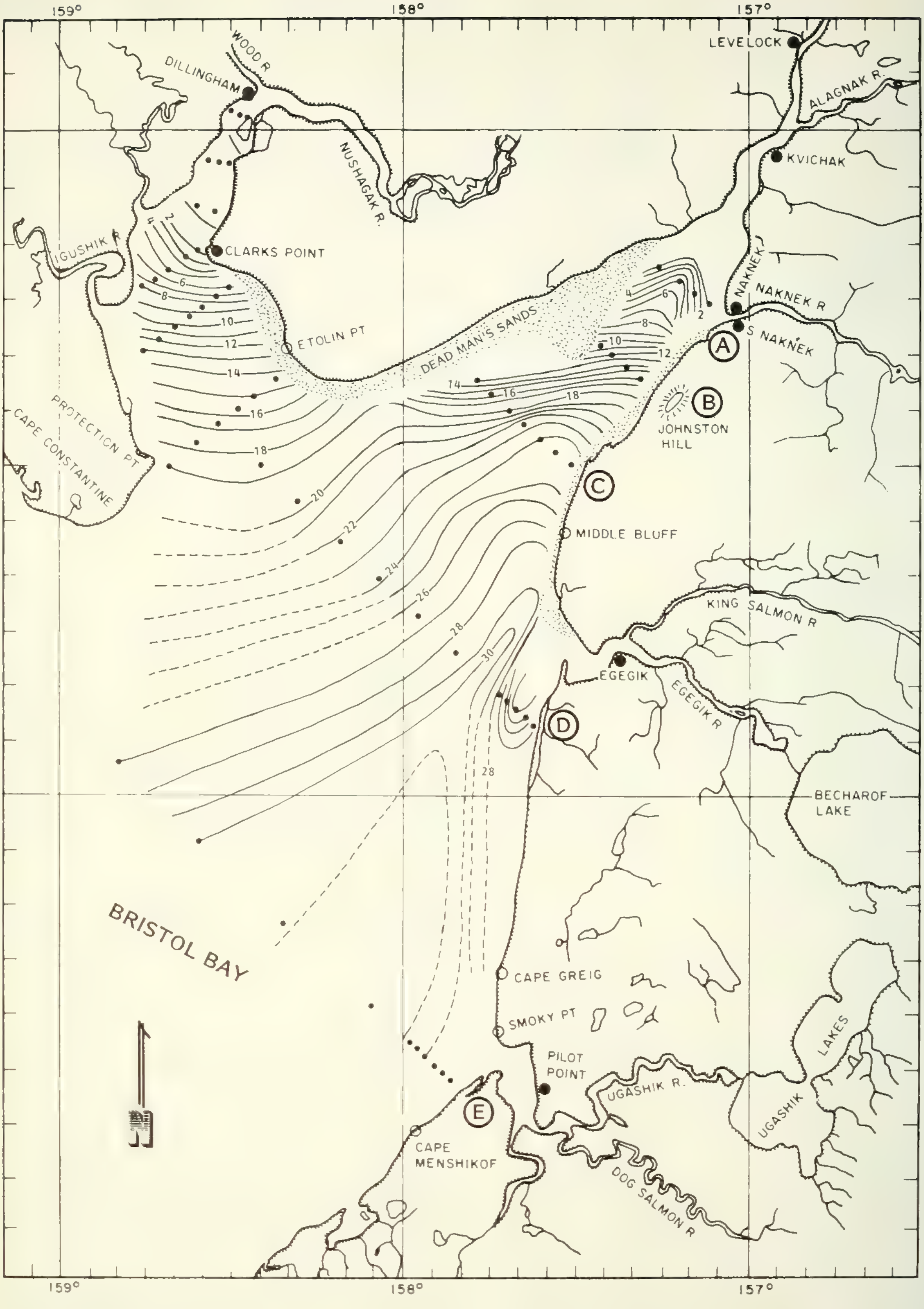

Figure 3.—Surface salinity (‰) at low tide, inner Bristol Bay, July and August 1966.

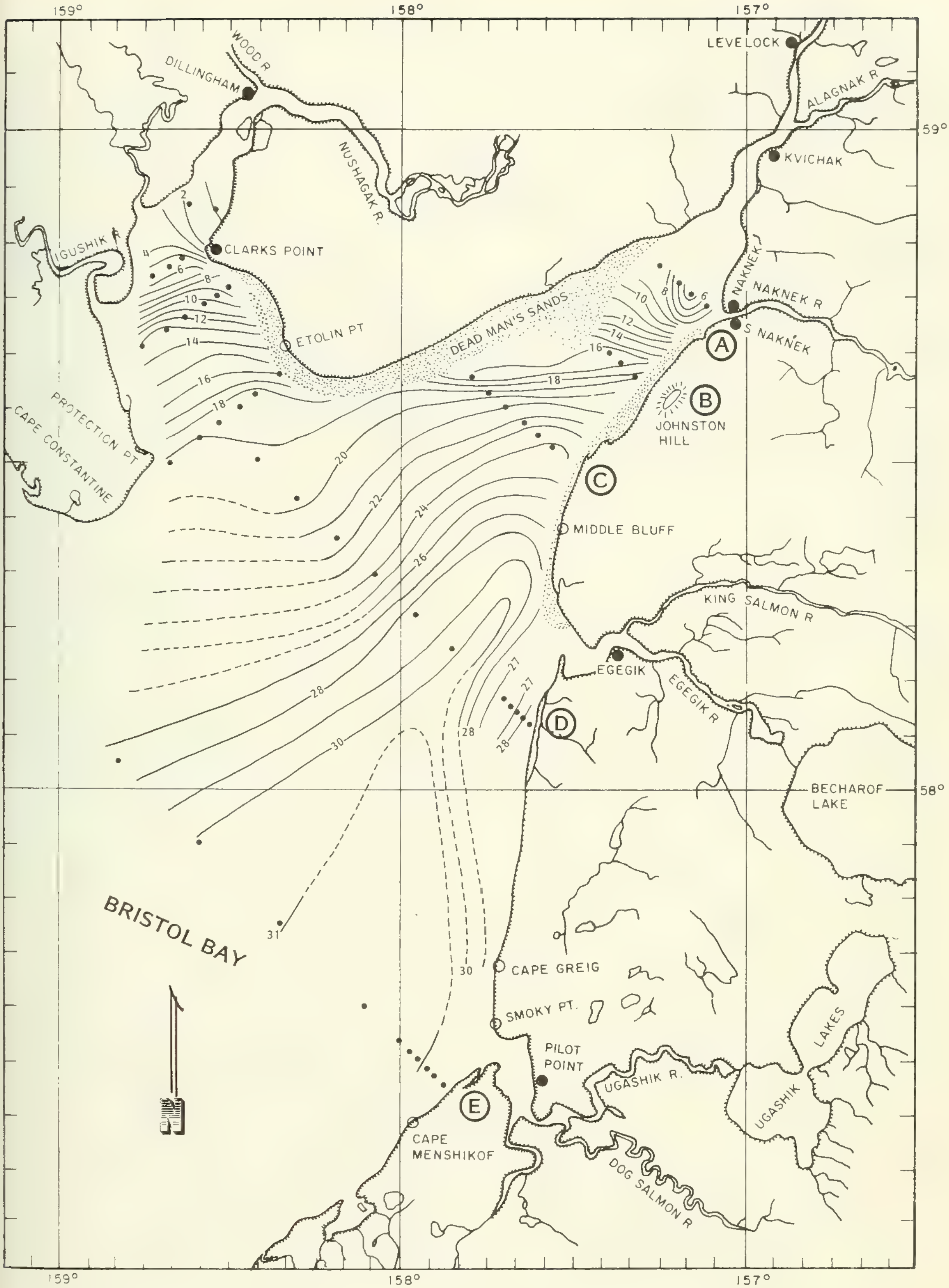

Figure 4.—Bottom salinity (‰) at low tide, inner Bristol Bay, July and August 1966.

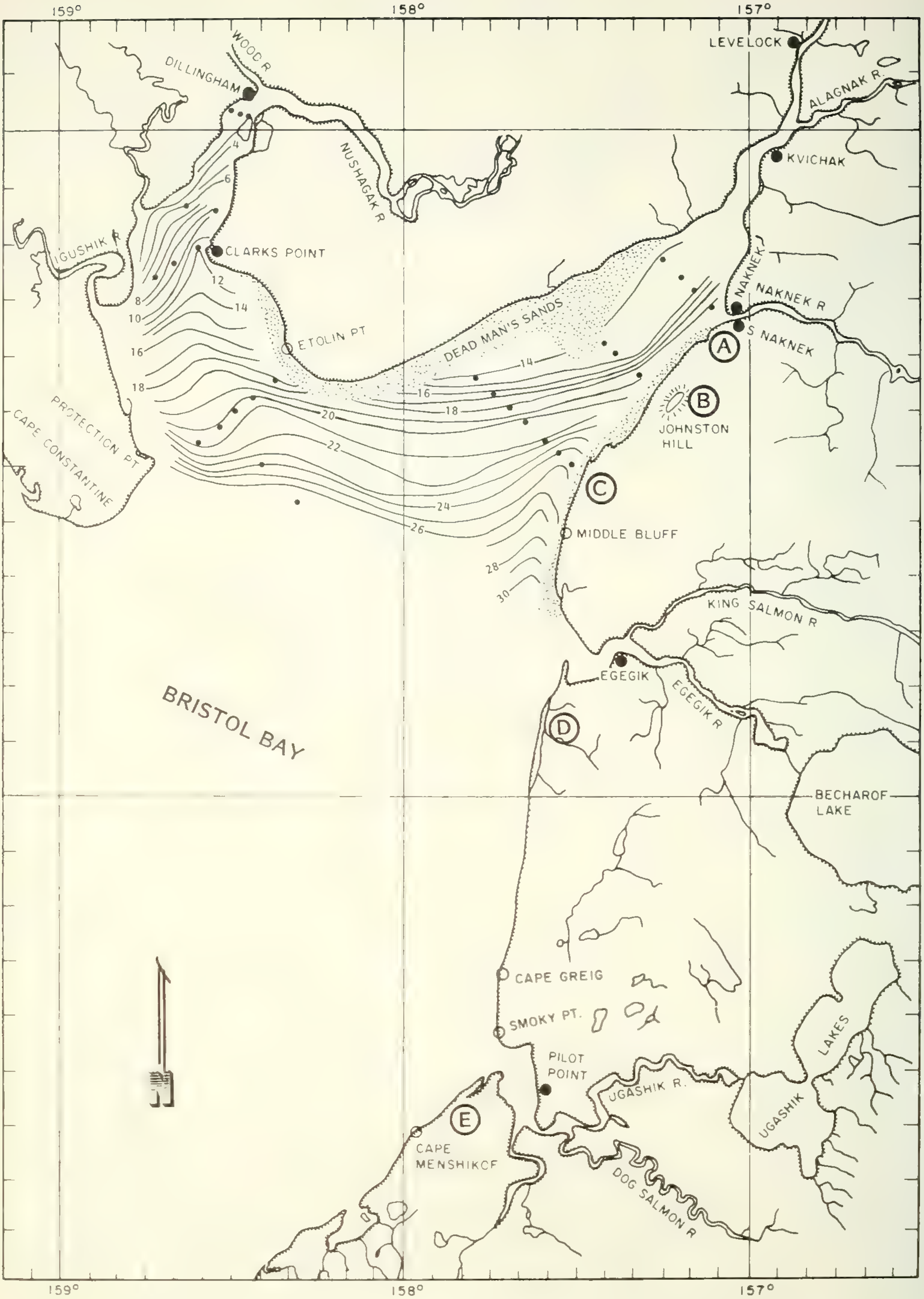

Figure 5.—Surface salinity (‰) at high tide, inner Bristol Bay, July and August 1966.

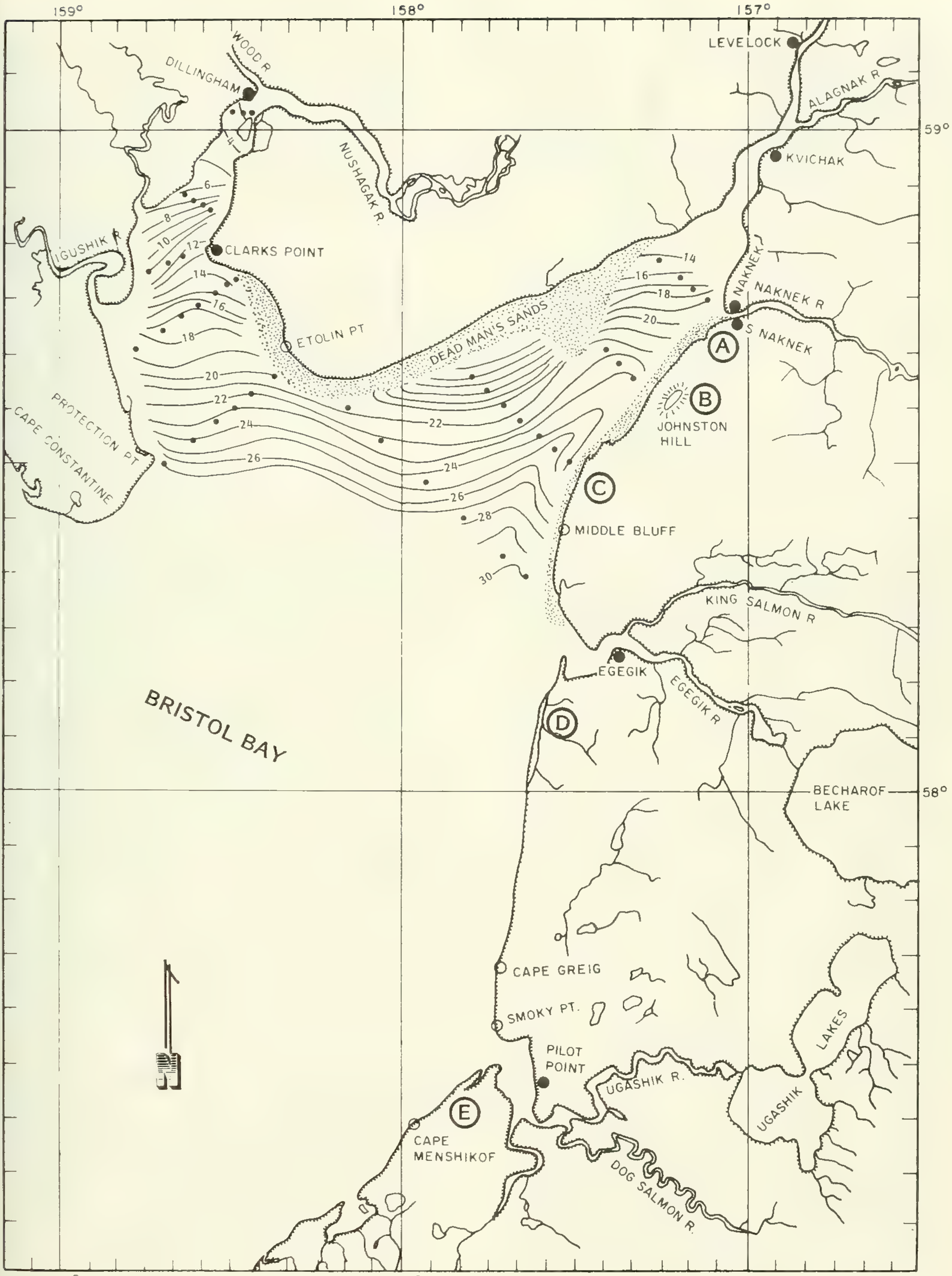

Figure 6.—Bottom salinity (‰) at high tide, inner Bristol Bay, July and August 1966.

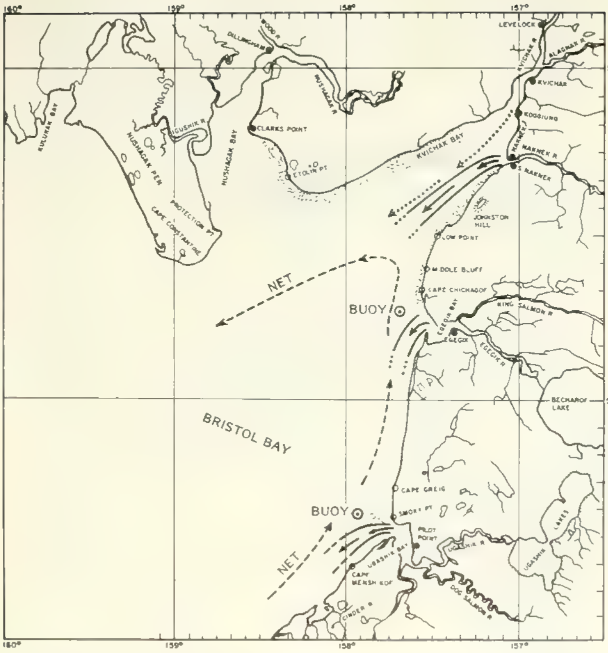

Figure 7.—Course of river waters in inner Bristol Bay on ebb tide as determined from course of dye releases in July and August 1965 and 1966. [Solid lines marking boundaries of river water denote area of actual observation; dotted lines indicate probable course; dashed lines indicate direction of net (nontidal) current. The direction of the net current is based on the results of previous oceanographic investigations (Dodimead et al. 1963) which showed a counterclockwise movement of water in this region.]

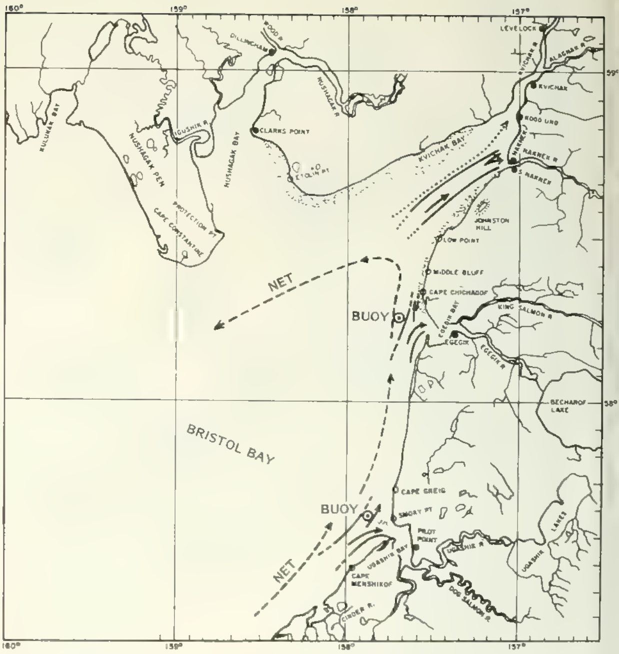

Figure 8.—Course of river waters in inner Bristol Bay on flood tide as determined from course of dye releases in July and August 1965 and 1966. [Solid lines marking boundaries of river water denote area of actual observation; dotted lines indicate probable course; dashed lines indicate direction of net (nontidal) current. The direction of the net current is based on the results of previous oceanographic investigations (Dodimead et al. 1963) which showed a counterclockwise movement of water in this region.]

tide at least 4.8 km north (above) of the mouths of Naknek, Egegik, and Ugashik rivers. This water moved toward shore and over the tideflats.

The path of the dye was followed as the vessel traveled at a speed of 3 knots. The vessel's position was accurately maintained by reference to prominent landmarks, marker buoys, and bottom topography (determined by comparing fathometer readings with navigational charts of the area). Because of the low wind velocity (less than 15 knots), the only factor affecting the vessel's position was the tidal current. Dye was followed visually for about 1 to 2 h after it was released; thereafter a fluorometer (Turner Model III) was used to detect it. Continuous sampling was carried out by pumping water from a depth of 1 m through the fluorometer as the vessel moved through the water. When readings indicated no dye was present, the course was altered 180° so that the dye patch was reentered.

Corrections for background fluorescence were applied to fluorometer readings during the tracking phase of the tracer studies. These were determined by running samples of pure river water from each of the rivers to be studied through the fluorometer and recording the instrument's dial readings. In addition, waters along the course of proposed tracer releases and the offshore portion of the study area were also sampled to determine the level of possible interfering background fluorescence. Only fluorometer dial readings above these background levels were considered to indicate the presence of dye.

Shear Lines.—Shear lines caused by adjoining currents having different speeds or directions affected the distribution of dye during ebb tide. These lines, a characteristic feature of the inner bay, were seen during relatively calm weather. They were not present during the flood tide but reformed, usually with some lateral variation of the axis, during the following ebb tide. The distribution of dye indicated that these lines marked the boundaries between waters leaving Naknek and Kvichak rivers and between the offshore water flowing seaward and the waters entering the bay from Egegik and Ugashik rivers. When surface turbulence was minimal, shear lines were observed about 6.5 km seaward from the mouth of the Naknek River. In Figure 7, the outer boundary denoting the course of the rivers corresponds to the general location of the shear lines. Dye released into Naknek, Egegik, and Ugashik rivers never crossed well-developed shear lines. Farther offshore the shear lines were not well developed and the dye dispersed laterally to some extent, no doubt because of decreased velocities and less difference in direction of separate currents. The northward extent of individual river waters during flood tide could not be identified by shear lines (Fig. 8).

The area of Kvichak Bay not occupied by Naknek River water was occupied by Kvichak River water (Figs. 7, 8). Kvichak River had a much greater volume of discharge than Naknek River, as indicated by the lower salinity on the northwest side of Kvichak Bay (Figs. 3, 6). Undoubtedly, waters of these two rivers mixed along their interface, particularly farther seaward during ebb tide when current velocities were reduced. Mixing between water masses also took place during flood tide, but Kvichak River water was predominant along the northwest shore and Naknek River water along the southeast shore of Kvichak Bay.

River runoff in this area moved southwest toward the northwest side of inner Bristol Bay (Fig. 7). By the time these waters had moved seaward as far as the Middle Bluff area, they were more than 8 km offshore. This movement of less saline water may be inferred also from the salinity distribution (Figs. 3, 6).

The course and distribution of Egegik River water is also clearly seen in the salinity distribution off the entrance to Egegik Bay (Figs. 3, 4). Salinity data were not obtained from the entrance of Ugashik Bay, but dye studies showed that the salinity pattern there should be similar to the one off Egegik Bay.

Plotting River Waters From Drift Cards

The drift card used in this study was developed by Martin (1967). It is made of a folded sheet (22 × 28 cm) of international orange plastic. A polystyrene float attached by galvanized staples to one end and a lead weight attached to the opposite end keep the card vertical in the water. The cards are serially numbered and bear printed instructions to the finder and spaces for recording requested recovery information.

On 2 June 1967, 1,007 cards were released at eight locations along the northeast side of inner Bristol Bay (Table 1). They were released in groups of 10 from an aircraft between 1 and 2 h after high slack tide so that those released near river mouths and bay entrances would move immediately out into the bay.

Cards were recovered in two ways: 1) I collected cards from beaches during aerial surveys conducted 6 wk or more after the cards were released, and 2) commercial salmon gill net fishermen returned cards which drifted into their area of operation. Of the 1,007 cards released, 141 were recovered (Table 1). The locations of recovery and resultant directions of drift are shown in Figures 9 to 16. Eighty-nine (8.8%) cards were recovered from beaches; parts of 31 more cards were also found on beaches but were unusable because they had lost identifying serial numbers.

Table 1.—Number and percent of drift cards recovered from releases in eight areas of inner Bristol Bay, 2 June 1967.

Release location (Figs. 9-16)	No. cards released	Cards recovered	
		Number	Percent
Kvichak River mouth	102	33	32.4
Naknek River mouth	100	44	44.0
Cape Chichagof	150	11	7.3
Egegik Bay entrance	101	5	4.9
Lat. 58°N	152	14	9.2
Cape Greig	151	21	13.9
Ugashik Bay entrance	101	4	4.0
Cape Menshikof	150	9	6.0
Total	1,007	141	14

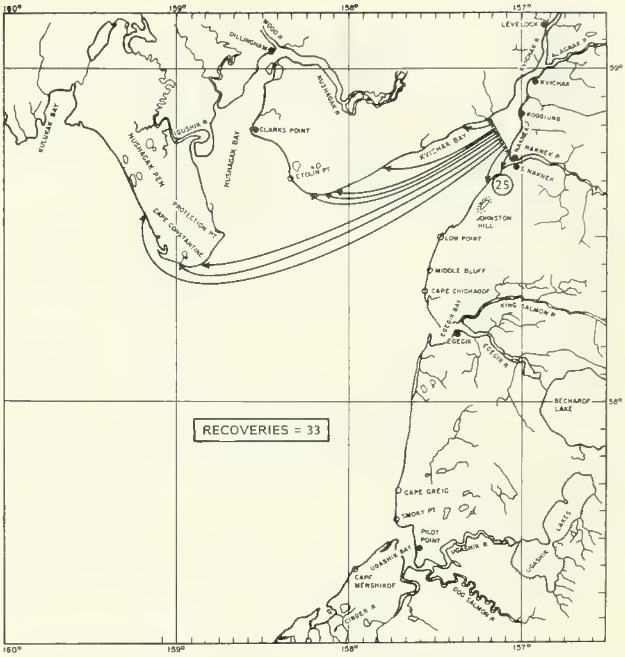

Figure 9.—Recovery locations of drift cards released across Kvichak River mouth, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

The direction of drift for cards released across the mouths of the Kvichak and Naknek rivers (Figs. 9, 10) was seaward in a southwesterly direction. Most cards recovered from these two releases were found between Naknek River mouth and Johnston Hill. The concen-

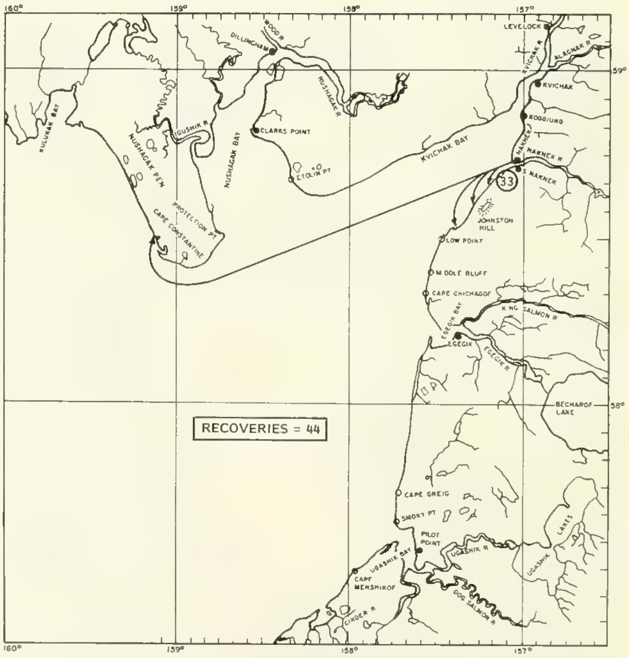

Figure 10.—Recovery locations of drift cards released across Naknek River mouth, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

tration of cards in this area was probably due to several factors. Water leaving Naknek River during the first several hours after high slack water moves seaward along the southeast side of Kvichak Bay. This movement must also occur for water above the Naknek River mouth along the east side of Kvichak River. Once the water level has dropped enough, the influence of a gravel bar off the entrance to Naknek River causes the main stream of Naknek River water to be directed farther offshore, and the water moving seaward along the east side of Kvichak River is also directed farther offshore. These flows converge and cause the shear line in the Naknek River mouth mentioned earlier. The emergence of the gravel bar at ebb tide also causes an eddy seaward of the bar which extends as far as the northern end of Johnston Hill (Fig. 10). Drift cards floating into this dead-water area at a certain stage of tide may have been prevented for a time from further seaward movement, and most were recovered from 2 to 17 days after release, indicating some had been confined in the area for many tidal cycles. More than half the cards recovered in the area were taken in stationary salmon gill nets.

Drift cards released in the mouth of Kvichak River and recovered elsewhere than in the area south of the mouth of Naknek River show that the seaward flow of Kvichak River water is along the northwest side of Kvichak Bay. Other than in the limited area mentioned, no cards released in Kvichak River were recovered on the southeast side of the bay (Fig. 9).

Cards released in Naknek River were recovered along the southeast side of Kvichak Bay as far as Low Point (Fig. 10), but no Naknek River cards were found seaward of this point on this side of the bay. One was recovered, however, on the west side of Nushagak Peninsula, indicating that the route of Naknek River water is offshore and toward the northwest side of inner Bristol Bay.

Drift cards released off Cape Chichagof and the entrance to Egegik Bay (Figs. 11, 12) show that movement of these waters is across and toward the northwest side of inner Bristol Bay; one card from each release was recovered north of the release site.

An eddy similar to the one at the Naknek River mouth probably exists south of Egegik River also. Most cards released between Egegik and Ugashik rivers were eventually recovered on beaches south of Egegik Bay (Figs. 13, 14).

Recoveries of cards from releases along lat. 58°N (Fig. 13), off Cape Greig (Fig. 14), at the entrance to Ugashik Bay (Fig. 15), and off Cape Menshikof (Fig. 16) show the course of the water to be north along the coast and ultimately toward the northwest side of Bristol Bay. No cards from any of these four releases were recovered to the south.

The distribution of drift cards furnished direct evidence on the courses followed by Kvichak, Naknek, Egegik, and Ugashik river waters in Bristol Bay and on the influence of the net or nontidal current on this pattern. The course followed is consistent with the course inferred from the horizontal salinity distribution in the area and from results of the tracer studies.

SYNOPSIS OF DISTRIBUTION OF RIVER WATERS

Results of the three methods of investigation permit a reasonable synopsis of the distribution of waters of the

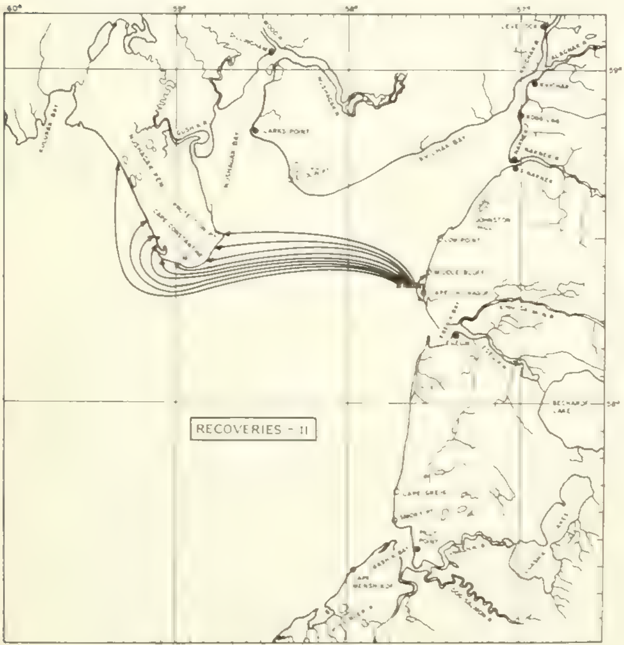

Figure 11.—Recovery locations of drift cards released off Cape Chichagof, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

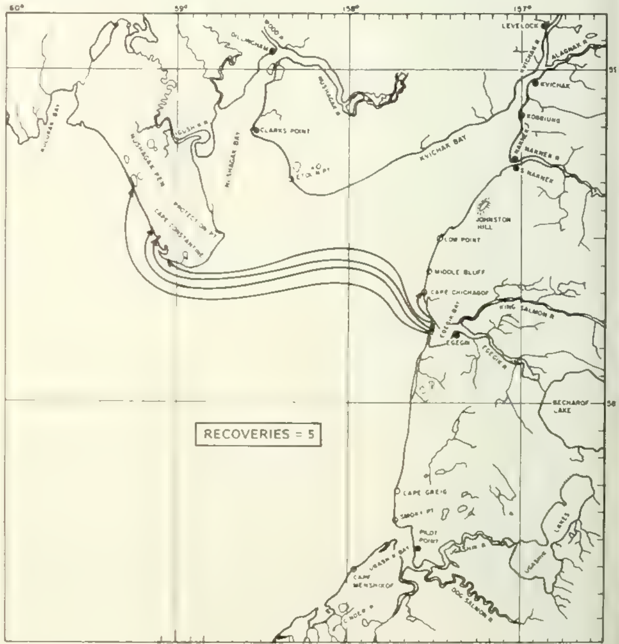

Figure 12.—Recovery locations of drift cards released across entrance to Egegik Bay, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

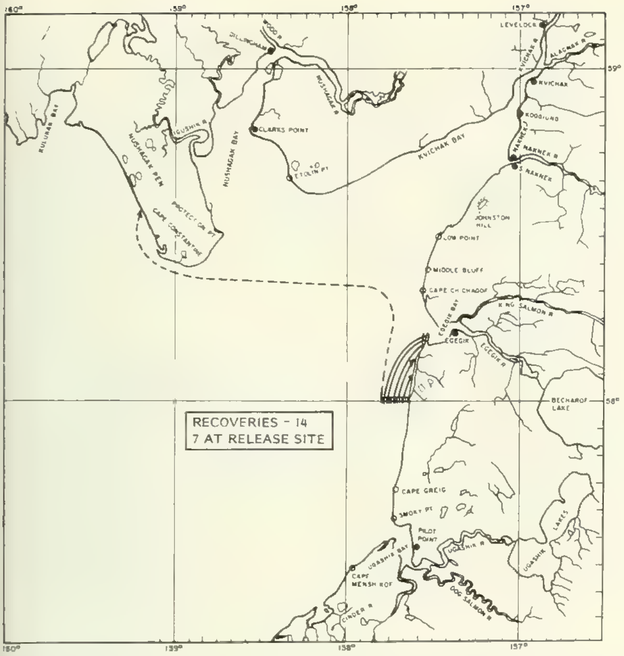

Figure 13.—Recovery locations of drift cards released along lat. 58°N, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

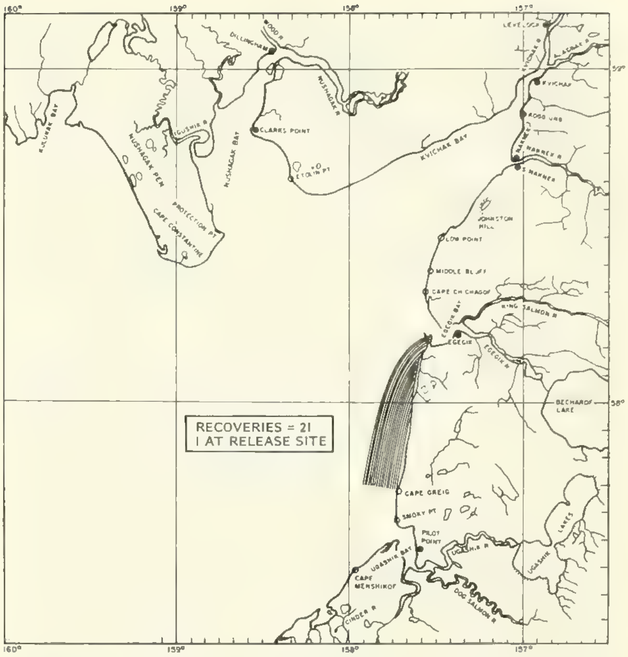

Figure 14.—Recovery locations of drift cards released off Cape Greig, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

major sockeye-salmon-producing river systems in inner Bristol Bay. The net seaward flow of river runoff water is along the northwest side of the bay, and the apparent net motion of seawater is toward the head of the bay on the southeast side.

The vertical distribution of salinity shows that the inner bay and the lower reaches of the rivers are vertically homogeneous. As a result, the circulation pattern in this region does not vary with depth. The motion toward the head of the bay, as pointed out earlier, extends to and perhaps somewhat above the Middle Bluff area in Kvichak Bay.

The distribution of salinity (Figs. 3-6) and the routes of drift cards (Figs. 9-16) both indicate that waters of rivers

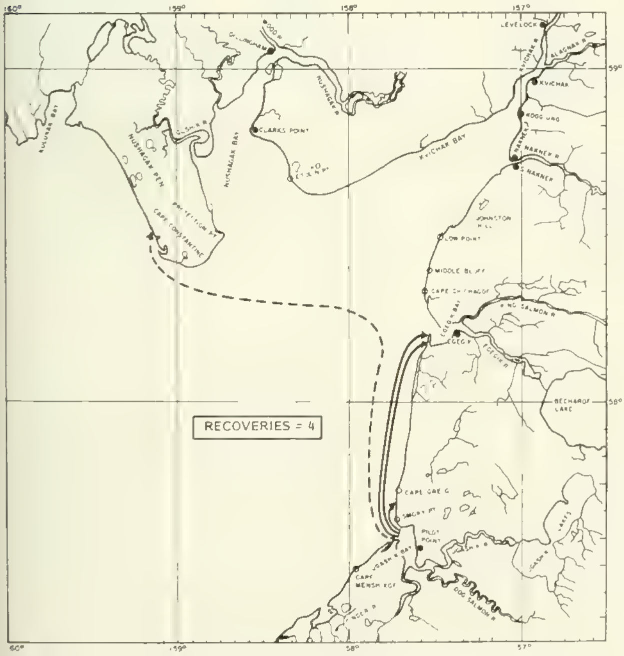

Figure 15.—Recovery locations of drift cards released across entrance to Ugashik Bay, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

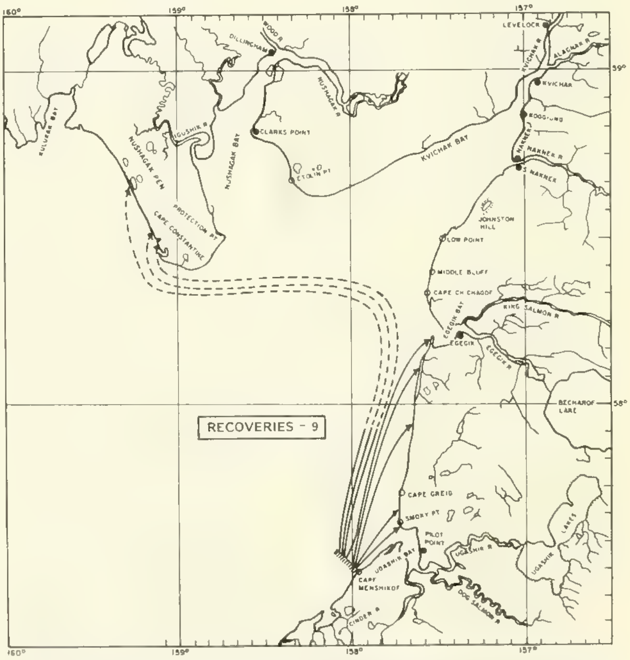

Figure 16.—Recovery locations of drift cards released off Cape Menshikof, inner Bristol Bay, 2 June 1967. (Lines from release site to recovery location indicate resultant direction of drift.)

draining Kvichak Bay move directly seaward along the northwest side of inner Bristol Bay past Cape Constantine. Between Egegik and Ugashik rivers and other rivers entering on the east side of the bay is a region of high-salinity water which has a net movement toward the head of Bristol Bay. Mixing and stirring will cause Egegik and Ugashik river waters entering the east side of the bay to mix with adjacent high-salinity water which has a net movement toward the head of the bay. Thus, the waters of Egegik and Ugashik rivers are carried above their mouths toward the head of the bay by the net current (Figs. 7, 8), and near Middle Bluff this water joins the flow of less saline water which is transported seaward on the northwest side of the bay.

On the southeast side toward the head of Bristol Bay and north of the mouth of Ugashik River, inshore water must become a mixture of Ugashik and Egegik river water rather than being largely Ugashik River water. Between the entrance of Egegik Bay and Middle Bluff, river water must be largely of Egegik River origin because it has a greater discharge than Ugashik River. Moreover, Ugashik River water is being diluted by lateral mixing with higher salinity offshore water during transport toward the head of the bay. In the Middle Bluff area, Egegik River water should predominate, but some Naknek River water could also be present. Kvichak River water must be well offshore in this area.

Tidal Influence

Flood tidal currents carry some Naknek, Egegik, and Ugashik river waters north or above their respective outlets into Bristol Bay, which cover tideflats exposed at low tide (Fig. 8).

Naknek River water transported north of the Naknek River mouth by the flood current mixes with Kvichak River water. This mixed water moves seaward on the succeeding ebb tide and should occur just to the west of the boundary marking the interface between water leaving Naknek and Kvichak rivers (Fig. 9). Thus, regardless of the striking separation of these waters shown by shear lines, during ebb tide there should be a gradation from Naknek to Kvichak river water from the southeast side to the northwest side of Kvichak Bay. In addition, there should also be a change from Naknek to Kvichak river water along the coast directly above Naknek River mouth during flood tide.

Egegik and Ugashik river waters transported north of the entrances to Egegik and Ugashik bays by flood tide (Fig. 8) mix with adjacent coastal waters. This mixture moves seaward on the succeeding ebb tide as part of the coastal water west of the shear line marking the separation of coastal water and waters leaving Egegik and Ugashik bays, respectively (Fig. 7). From the southeast to the northwest side of Bristol Bay in these regions, there should be a change from the coastal water of Egegik and Ugashik origin to high-salinity water, and then to low-salinity water originating from 9 of the 10 major sockeye-salmon-producing rivers entering inner Bristol Bay.

An additional effect of tidal action on the distribution of river water is apparent in the salinity distribution in the inner bay at low and high tides (Figs. 3-6). The distribution of certain isohalines at low and high tides suggests that a portion of the river runoff water that moves seaward from Kvichak Bay may actually be transported into Nushagak Bay at high tide. This river water would be mainly of Kvichak and Naknek origin, but perhaps some would be of Egegik origin.

Effects of Wind

My studies were done when wind velocities were generally less than 15 knots, and the effects of prolonged strong winds on the distribution of river waters were not evaluated. Strong winds undoubtedly increase the horizontal mixing between individual river waters and between river water and seawater. Drift cards afloat for 6 wk or more assumed a distribution similar to the course inferred from the salinity distribution of the area. The cards must have encountered winds exceeding 30 knots, which suggests that the circulation pattern determining the course followed by all river waters to the northwest side of inner Bristol Bay may not have changed during periods when winds exceeded 15 knots.

In the summer months, winds in Bristol Bay are generally from the southeast, and because the movement of surface water is to the right of wind direction in the Northern Hemisphere (Sverdrup et al. 1942), these southerly winds move water onshore or toward the head of Bristol Bay. Prolonged periods of strong winds may be expected then to expand or reduce the horizontal distribution of given river waters in the inner bay. Under such conditions, one would expect it is largely Kvichak River water (which occupies the northwest side of Kvichak Bay) that is moved toward the east side of the bay and that considerable mixing between Kvichak and Naknek river waters would occur. The same situation holds true for the other rivers entering the bay. Although the horizontal distribution of individual river waters may be expected to expand or be reduced under prolonged strong winds, their seaward course should remain essentially the same.

SUMMARY

Hydrographic studies were carried out in inner Bristol Bay to determine the seaward course and distribution of the waters of major sockeye-salmon-producing river systems draining into the bay. These studies were conducted in conjunction with investigations of the early marine life and distribution of adult sockeye salmon while in Bristol Bay. They included: 1) determining the vertical and horizontal distributions of salinity in the inner bay; 2) tracking and plotting the distribution and course of Naknek, Egegik, and Ugashik river waters during flood and ebb with Rhodamine B dye; and 3) plotting the seaward course of plastic drift cards released at several locations in inner Bristol Bay.

The results of the hydrographic studies showed that the net seaward flow of the lighter and less saline river runoff water is along the northwest side of inner Bristol Bay. The net motion of high-salinity water toward the head of Bristol Bay was shown to transport with it the waters of Ugashik and Egegik rivers, which enter the bay on the southeast side. Near Egegik Bay to Middle Bluff these waters joined the seaward flow of Kvichak and Naknek river waters, which enter at the head of Bristol Bay. Waters of these four rivers, along with the large volume of water from the rivers entering Nushagak Bay, are eventually transported to, and moved seaward on, the northwest side of Bristol Bay. Dye tracer studies showed that Naknek, Egegik, and Ugashik rivers were similar to each other in the courses followed during ebb and flood tides. Flood tide currents, along with the nontidal current, transported water from Egegik and Ugashik rivers above or north of the entrance to Egegik and Ugashik bays, respectively.

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Wind Stress and Wind Stress Curl Over the California Current

Craig S. Nelson

August 1977

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NOAA Technical Report NMFS SSRF-714

Wind Stress and Wind Stress Curl Over the California Current

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August 1977

U.S. DEPARTMENT OF COMMERCE
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National Oceanic and Atmospheric Administration
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CRAIG S. NELSON[1]

ABSTRACT

Historical surface marine wind observations are summarized by 1-degree square areas and months to describe the seasonal distribution of wind stress over the California Current. Off the coasts of southern California and Baja California, an alongshore equatorward component of surface wind stress is present throughout the year. The distributions of wind stress north of Cape Mendocino are characterized by marked changes in direction and magnitude between summer and winter. The predominant wind stress maximum shifts northward coherently from off Point Conception in March to south of Cape Blanco in September, and extends approximately 500 km in the offshore direction and 1,000 km in the alongshore direction. Maximum values of surface wind stress occur during July near Cape Mendocino.

The wind stress curl is positive near the coast and negative in the region offshore. A line of zero wind stress curl parallels the coast 200 to 300 km offshore, except off central Baja California. The patterns of wind stress curl are consistent with the existence of an equatorward Sverdrup transport offshore and a poleward transport near the coast.

INTRODUCTION

Spatial variation of surface wind stress has long been recognized as a fundamental quantity in discussions of the wind-driven ocean circulation. Sverdrup's (1947) transport balance relates the vertically integrated meridional mass transport in the interior ocean to the open ocean wind stress curl. Munk (1950) extended the theory to a closed basin and estimated the mass transports for several oceanic circulations from a knowledge of the wind stress alone. Recent theoretical developments have attemped to explain the well-known westward intensification, but have largely ignored the wind-driven circulation in eastern boundary currents, such as the California Current.

The California Current flows southeastward along the west coast of the United States as one branch of the large anticyclonic gyre in the North Pacific Ocean. The predominant surface current occurs between a cell of high atmospheric pressure to the west and a continental thermal low situated over California. Seasonal variations in the direction and strength of the surface wind are related to shifts in location of the high pressure system and intensification of the semipermanent thermal low.

The basic flow of the California Current system may be described in terms of the local wind stress (Reid et al. 1958). The equatorward surface current and poleward undercurrent are typical of eastern boundary currents (Wooster and Reid 1963). Munk (1950) has suggested that the average wind distribution off California is consistent with the existence of an equatorward surface current offshore and a poleward current inshore. However, lack of an adequate data base has precluded a detailed analysis of the relationships among the distributions of surface wind stress, the southward flowing California Current, and the northward flowing countercurrent which appears seasonally off the coasts of California, Oregon, and Washington.

A related phenomenon in eastern boundary currents is the process of coastal upwelling. The role of upwelling in bringing nutrients into the surface layers where they are available for organic production is widely recognized. According to the simplified model (Sverdrup 1938), equatorward wind stress parallel to the coast induces flow in the surface Ekman layer of the ocean which is deflected offshore by the earth's rotation (Ekman 1905). When this occurs over an expanse of coast where horizontal surface flow cannot compensate for that driven offshore, the balance is maintained by upwelling of subsurface water. Smith (1968) suggested that wind stress, being the driving force in this mechanism, may be the most important single variable in coastal upwelling.

Previous estimates of the surface wind stress over the oceans have been based primarily on wind data taken from the U.S. Hydrographic Office Pilot Chart wind roses (Hidaka 1958; Hellerman 1967). The large-scale features evident in these distributions are consistent with the occurrence of the major cyclonic and anticyclonic circulations in the oceans. However, the coarse spatial and temporal resolution of these data (5-degree quadrilateral space average and 3-mo time average) are not adequate to describe the locally driven processes evident in the California Current system.

Wooster and Reid (1963) used Hidaka's estimates of surface wind stress to calculate the offshore Ekman transport and described the locations and seasonal timing of the major coastal upwelling regimes in terms of these "upwelling indices." Bakun (1973) extended the concept of the upwelling index by computing estimates of Ekman transport from routinely available analyzed surface atmospheric pressure fields. Temporal fluctuations are well described by these data. However, both the derived quantities based on Hidaka's wind stress data and Bakun's upwelling indices suffer from an inability to characterize small-scale features of the Ekman transport field, particularly near the coast. For example, where these data may indicate surface divergence on the large scale, smaller scale surface convergence might exist, with associated effects on distributions of organisms within the coastal upwelling zone.

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This report provides more detailed descriptions of the surface wind stress distributions over the California Current. The study differs from previous work by calculating monthly mean values on a 1-degree square area basis. Surface marine wind observations have been utilized in the computations. Roden (1974) evaluated the surface wind stress on a 1-degree latitude-longitude grid. However, Roden's distributions were derived from monthly mean surface atmospheric pressure analyses based on a 5-degree latitude-longitude grid. Thus, any information concerning space scales smaller than 5 degrees is due to the particular interpolation scheme used to refine the data to a 1-degree grid, rather than due to observed data.

The monthly mean data described in this report adequately resolve the seasonal cycle, which is the dominant time scale for coastal upwelling (Mooers et al. 1976). The high resolution in space and time may provide the observational background for more detailed investigations of the relationships among the local wind stress distributions, the equatorward surface current offshore, the poleward surface and subsurface flow inshore, and distributions of certain species of fishes, such as the northern anchovy, *Engraulis mordax*, and the Pacific mackerel, *Scomber japonicus*.

DATA REDUCTION

The monthly mean distributions of surface wind stress presented in Appendix I are based on summaries of data contained in the National Climatic Center's file of surface marine observations (Tape Data Family-11). The total file contains approximately 40 million individual ship reports dating from the mid-19th century. Over 1 million of the reports are within the area of the California Current system.

I have compiled long-term composite monthly fields of surface wind stress on a 1-degree square area basis within the geographical area outlined in Figure 1. The data grid extends from lat. 20°N to 50°N and parallels the coastline configuration, extending 10 degrees of longitude in the offshore direction. Each 1-degree quadrilateral is centered on a whole degree of latitude and longitude. Approximately 25% of the total available reports contain positions recorded to the nearest whole degree of latitude and longitude. The grid orientation used in this study thus minimizes spatial bias which might be introduced by summarizing the data according to the Marsden square numbering system.

The historical data contain errors in position, measurement, and processing. A single pass editor was used to remove gross errors in the data, including duplicate reports (0.5%), position errors (0.1%), and measurement errors (0.5%). Erroneous wind directions and wind speeds greater than 100 m s^{-1} were removed. Reports of variable winds were treated as calms.

An estimate of the surface wind stress was calculated for each wind velocity report according to the bulk formula:

$$(\tau_x, \tau_y) = \rho_a C_D \left(|\vec{W}_{10}|\, U_{10},\ |\vec{W}_{10}|\, V_{10} \right) \qquad (1)$$

where τ_x and τ_y denote the eastward and northward components of stress, ρ_a is the density of air which was considered to have a constant value of 0.00122 g cm^{-3}, $|\vec{W}_{10}|$ is the observed wind speed, and U_{10} and V_{10} are the eastward and northward components of the wind velocity measured at a height of 10 m. The empirical drag coefficient C_D, referred to the 10-m level, was given a constant value of 0.0013 (Kraus 1972).

The resultant long-term monthly mean wind stress vectors were computed as the arithmetic means by east and north components of all available reports from 1850 to 1972 within a 1-degree square area. The appropriate average is defined in Equation (2):

$$(\bar{\tau}_x, \bar{\tau}_y) = \frac{1}{N} \sum_{i=1}^{N} (\tau_x, \tau_y)_i \qquad (2)$$

where N is the total number of reports within a 1-degree square area and month. The values $(\tau_x, \tau_y)_i$ were evaluated according to Equation (1). A mean value for each long-term month and square is therefore formed from a data set which is independent of all other months and squares. The monthly fields of surface wind stress are displayed in Appendix I as vector quantities (Charts 1 to 12) and as east (Charts 13 to 24) and north (Charts 25 to 36) components. No attempt has been made to smooth the fields, either by removing data which do not appear to fit the distributions or by applying objective smoothing procedures. The mean values were contoured by computer and "bull's-eyes" in the contours, even where they possibly reflect erroneous data, were left in the charts as indications of the general degree of consistency in the composite distributions. The bull's-eyes may reflect either a paucity of ship observations, or extreme variability associated with inadequate sampling of strong winds.

The spatial distribution of observations is biased in that "ship of opportunity" reports are generally confined to coastwise shipping lanes. Contours indicating the total numbers of observations per 1-degree square area are shown in Figure 2. The highest density of reports is found within 300 km of the coast, exceeding 40,000 observations per 1-degree square in the area south of Point Conception. The number of reports per 1-degree square

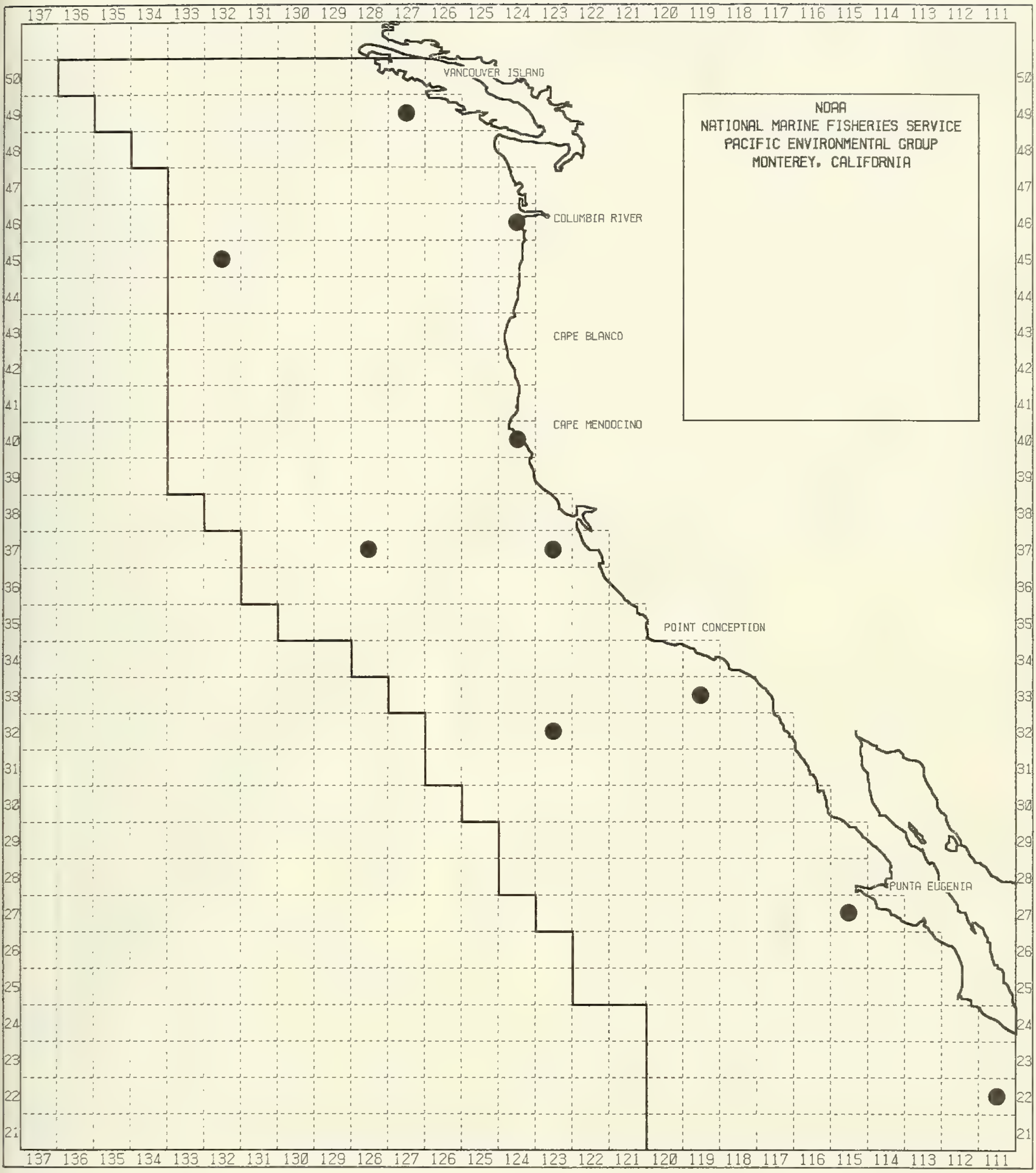

Figure 1.—Chart of the west coast of the United States showing the grid of 1-degree squares used for summaries of wind observations. Large dots indicate squares for which frequency diagrams are displayed in Figures 9-12.

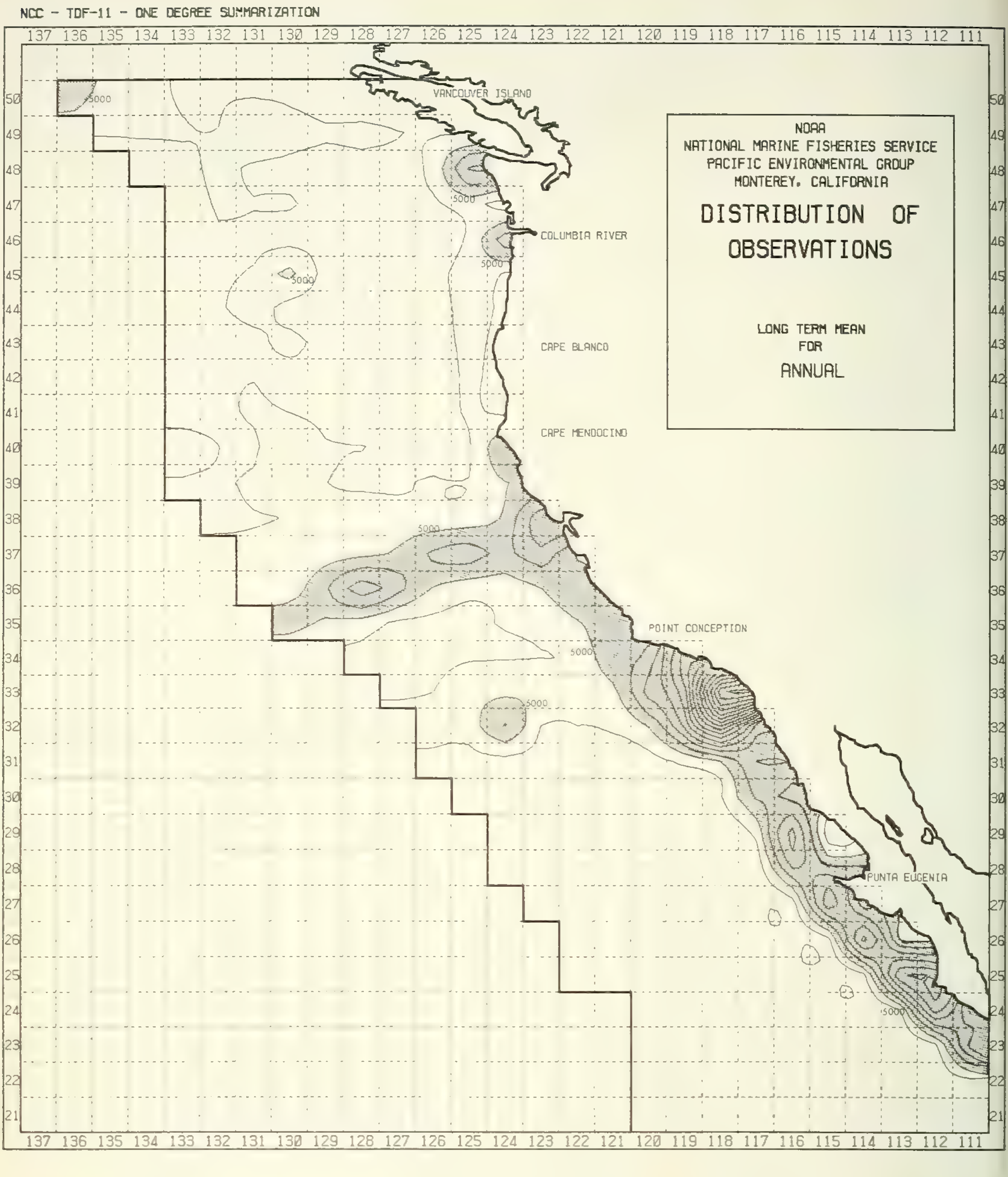

Figure 2.—Distribution of observations per 1-degree square. The contour interval is 2,500 observations. Values greater than 5,000 are shaded.

per month varies from less than 20 (in January off Vancouver Island) to more than 3,800 (in May off Los Angeles). A significant increase in the number of observations is evident along the shipping route between San Francisco and Hawaii. Less than 20% of the vector means are based on fewer than 50 observations per 1-degree square per month. Some temporal bias may also exist, since approximately 50% of the total reports have been taken since 1945. However, the general coherence of the resulting vector fields indicates that the composite wind stress distributions can be used to describe the dominant seasonal cycle in the California Current system.

The historical surface marine observations used in this study have been obtained primarily from ship logs, ship weather reporting forms, and published ship observations. The reports differ markedly in method and precision of measurement, ranging from observations made aboard 19th century vessels, to those taken aboard modern oceanographic research ships. Possible errors in wind measurement have been summarized by Hantel (1970). These include influences of anemometer height, atmospheric stability, wind gusts, and duration of the observation. Sources of error in wind estimates include the wind effects observed, error in determining the true wind from the observed apparent wind, and the unavoidable subjectivity of the observer.

A substantial portion of the historical data consists of wind reports based on the antiquated Beaufort wind force scale (Kinsman 1968). Table 1 lists the conversion scale between the Beaufort number and the equivalent wind speed in knots and meters per second. These estimates are equivalent to a wind speed measurement at a height of 10 m.[2]

Table 1.—Wind speed equivalents of Beaufort force estimates in knots and meters per second.

Beaufort	Knots	ms^{-1}
0	0	0.0
1	2	0.9
2	5	2.4
3	9	4.4
4	13	6.7
5	18	9.3
6	24	12.3
7	30	15.5
8	37	18.9
9	44	22.6
10	52	26.4
11	60	30.5
12	68	34.8

Based on the documentation for the National Climatic Center's data file (TDF-11),[3] a determination was made of the number of wind observations estimated and those actually measured by an anemometer. Approximately 35% of the reports in this study consisted of Beaufort wind force estimates. An additional 53% of the reports were estimated wind speeds which did not correspond to the Beaufort wind force scale. Less than 12% of the total reports consisted of measured quantities.

In addition to the errors introduced by the necessary calculation of true wind from the measured apparent wind, the reported directions varied in precision. Resolution varied from ±11.25° to ±5° corresponding to observations based on 16 points of a 32-point compass and a 36-point compass, respectively.

The above considerations lead to the conclusion that random observational errors may be as large as real nonseasonal fluctuations in the distributions of surface wind stress. The problem may be formalized by expressing the individual stress estimates τ_x and τ_y as the sums of monthly mean values $\bar{\tau}_x$ and $\bar{\tau}_y$, deviations from the monthly means τ'_x and τ'_y, and error terms τ^{ϵ}_x and τ^{ϵ}_y. The second and higher moment statistics will consist of the nonzero correlations between the deviations from the monthly means and the error terms. If the observational errors are greater than the real fluctuations, then the standard deviations of the monthly means will reflect observational noise rather than actual nonseasonal variability. However, provided that these errors are not systematic, the resultant first moment statistics will be the appropriate estimates of the monthly mean wind stress.

The standard error of the mean provides a more appropriate quantitative measure of the relation between the standard deviation of a set of measurements and the precision of the mean value of the data set (Young 1962). The standard errors of the means are defined by:

$$(S_{\bar{\tau}_x}, S_{\bar{\tau}_y}) = (S_{\tau_x}/\sqrt{N}, S_{\tau_y}/\sqrt{N}) \qquad (3)$$

where $S_{\bar{\tau}_x}$ and $S_{\bar{\tau}_y}$ are the standard errors of the means of the eastward and northward components, respectively, S_{τ_x} and S_{τ_y} are the standard deviations, and N is the number of observations. Large values of N and small values of S_{τ_x} and S_{τ_y} correspond to mean values $\bar{\tau}_x$ and $\bar{\tau}_y$ which closely approximate the population means.

The computed standard errors of the means and numbers of observations of each 1-degree square area and long-term month are tabulated in Appendix II. Values less than 0.1 dyne cm^{-2} occur throughout a large portion of the summary area, although spatial and seasonal dependence is evident. Standard errors greater than 0.1 dyne cm^{-2} occur over large areas north of Cape Mendocino and between 500 and 1,000 km off the coast of Baja California. High values are generally associated with regions of sparse date, although inadequate sampling of intense storms may also lead to large values. Typical ratios of the standard error to the mean stress $(S_{\bar{\tau}_x}/\bar{\tau}_x)$ range from 0.01 off southern California to 1.0 offshore from Cape Blanco. Near Cape Mendocino, this ratio varies between 0.02 and 0.10. Minimum values adjacent to the coast south of lat. 40°N and along the shipping lane between San Francisco and Hawaii are well correlated with the distribution of observations shown in Figure 2.

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[2] Resolution 9, International Meteorological Committee, Paris, 1946.

[3] National Climatic Center, Tape Data Family 11, NOAA/EDS/NCC, Asheville, N.C.

DEPENDENCE OF STRESS ESTIMATES ON C_D

A constant drag coefficient was used to compute the surface wind stress data displayed in Appendix I. Stress calculations were made for each wind report and then averaged to form the resultant monthly mean vectors. Different results might have been obtained if the stress were calculated from monthly mean wind data, or if effects of atmospheric stability were considered. These aspects are discussed below.

Errors associated with the observational data used in this study place certain limitations on the form of the bulk exchange formula expressed in Equation (1). If measurement errors are large, there may be little value in refining the parameterization by replacing C_D by a variable drag coefficient which is a function of stability or wind speed. Even with a constant C_D, the bulk formula contains nonlinearities. Therefore, the drag coefficient must be appropriate for the particular time-averaged winds used in the calculations. That is, a drag coefficient appropriate for synoptic wind observations would not be appropriate for winds averaged over a month.

Effects of Averaging

The empirically derived transfer coefficient C_D, determined by eddy correlation and profile methods, is based on wind measurements averaged over periods of 30 to 60 min. Pond (1975) indicated that the appropriate values of $|\vec{W}_{10}|$, U_{10}, and V_{10} should be obtained over a period of a few minutes to a few hours at most. If the surface stress were calculated using winds averaged over much longer periods, a higher drag coefficient would be required. The surface stress calculated from a monthly mean surface wind field will be significantly less than the surface stress field calculated as the mean of the individual stress estimates, if the same drag coefficient is used and all other parameters are held constant.

The difference described above has been determined for the data used in this study. For each 1-degree square area and long-term month, the following ratio has been calculated:

$$(C_D)_{\text{equ}} = |\overline{\vec{\tau}}| \Big/ [\rho_a (|\overline{\vec{W}_{10}}|)^2] \tag{4}$$

where $\overline{|\vec{\tau}|}$ is the magnitude of the monthly mean surface stress, $|\overline{\vec{W}_{10}}|$ is the magnitude of the monthly mean surface wind, and $(C_D)_{\text{equ}}$ is an equivalent drag coefficient. This is the value which would be necessary to make the stress values calculated from the monthly mean wind data agree with the values calculated as the means of individual stress estimates.

Values of $(C_D)_{\text{equ}}$ for the months of June and December are shown in Figures 3 and 4. The values are significantly different from the constant value of $C_D = 0.0013$ employed in this study. In all cases, $(C_D)_{\text{equ}}$ is greater than C_D. Spatial and seasonal variability is marked. There is a tendency for much higher values in the northern section of the grid than in the southern area. Large values of $(C_D)_{\text{equ}}$ are more evident in December than in June. Geographical and seasonal variations in the quantity $(C_D)_{\text{equ}}$ agree with the general geographical and seasonal fluctuations in meteorological conditions over the northeast Pacific Ocean. This would indicate that a large part of the monthly variance of the wind stress data is due to actual intramonth fluctuations and not due to observational errors. If a resultant surface wind stress were calculated from the monthly mean wind field, these calculations imply that the wind stress estimates would be underestimated, on average, by as much as 50% to 100%. The departures would be even larger off Oregon and Washington.

Effect of Atmospheric Stability

Investigations on the functional form of the drag coefficient have alternately suggested constant values, or a dependence on wind speed. Wilson (1960) gave a detailed review of the available data and adopted values of $C_D = 0.0024 \pm 0.005$ for strong winds and $C_D = 0.0015 \pm 0.0008$ for light winds. Smith (1970) proposed a constant value of $C_D = (1.35 \pm 0.34) \times 10^{-3}$. Wu (1969) adopted the form $C_D = (0.5 \times \overline{U}_{10}^{1/2}) \times 10^{-3}$. Considering the large scatter in the open ocean determinations of C_D, the lack of conclusive data at wind speeds greater than 15 ms^{-1}, and the lack of agreement among individual observers, a constant value for the neutral drag coefficient was used in this study.

Recent investigations by Davidson (1974) and Denman and Miyake (1973) have demonstrated the dependence of the drag coefficient on atmospheric stability and the spectral shape of the ocean wave field. A generally accepted formulation of the dependence of C_D on wave properties does not seem well enough established to be incorporated in the calculations of surface wind stress based on historical ship observations. However, effects of atmospheric stability on the momentum exchange may be significant in regions where seasonal upwelling typically produces a stable boundary layer.

The specific effects of atmospheric stability on the exchange of momentum have not been completely determined and are still under investigation. However, for a given wind speed, the effect of stable (unstable) stratification is to decrease (increase) the magnitude of the momentum exchange (surface wind stress) across the atmosphere-ocean interface.

In order to investigate the effects of atmospheric stability, the monthly mean fields of surface wind stress were recomputed, replacing the constant value C_D in Equation (1) by a coefficient varying with atmospheric stability. Deardorff (1968) defined the bulk Richardson number as an appropriate dimensionless measure of atmospheric stability. Deardorff's method was adopted to parameterize the dependence of the drag coefficient on stability, while neutral stability was assumed when the absolute value of the air-sea temperature difference was

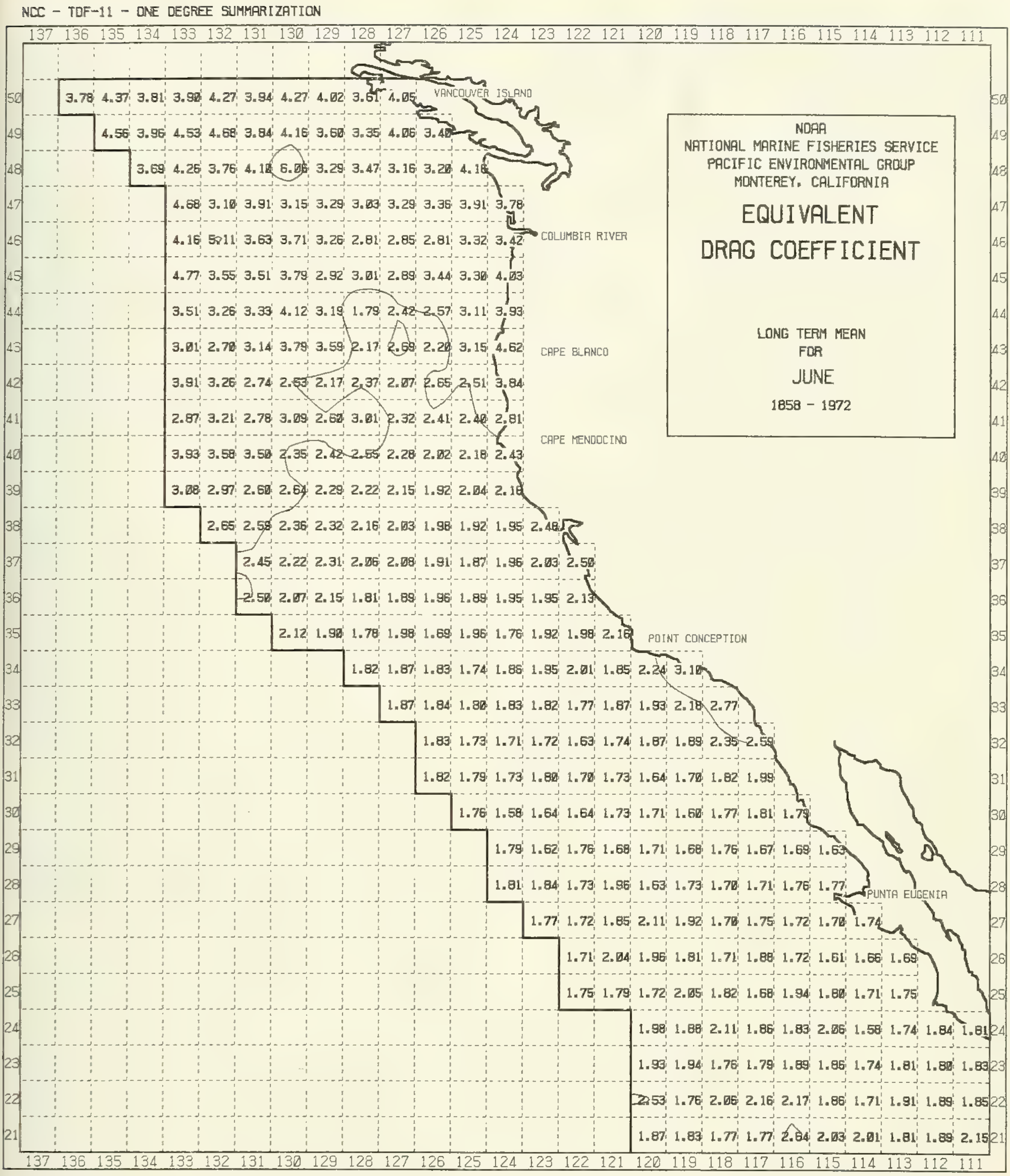

Figure 3.—Equivalent neutral drag coefficient for June. The plotted value is the drag coefficient (× 10³) appropriate for wind observations averaged over a month. The contour interval is 2.5.

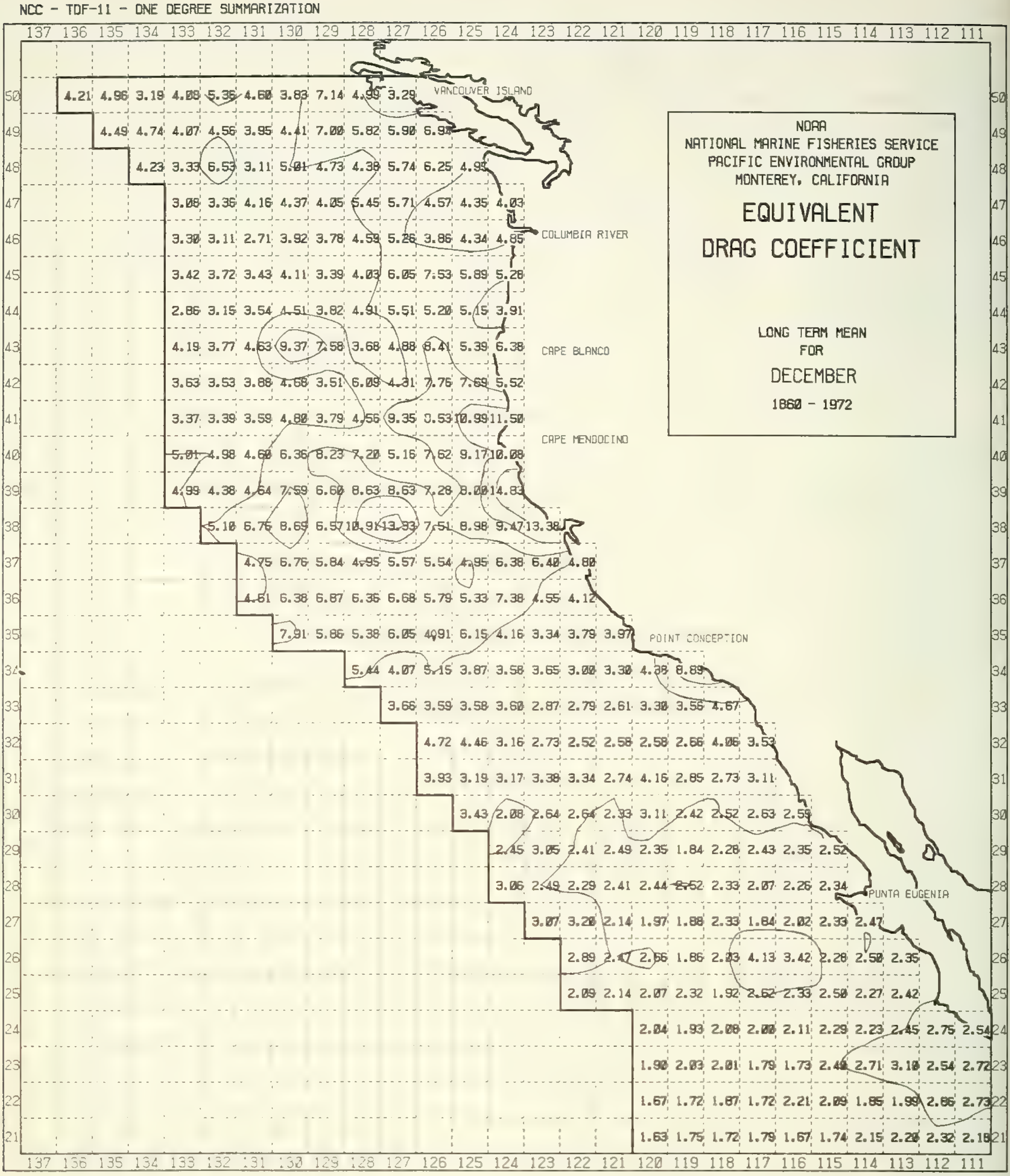

Figure 4.—Equivalent neutral drag coefficient for December. The plotted value is the drag coefficient (× 10³) appropriate for wind observations averaged over a month. The contour interval is 2.5.

less than 1°C. Details of the calculations will be reported elsewhere.

The effect of atmospheric stability was computed as a percentage increase (decrease) in the magnitude of the monthly mean surface wind stress above (below) the appropriate neutral values. The following ratio was calculated:

$$R = \left(\frac{\left|\overline{\vec{\tau}}\right|_{\mathrm{var}}}{\left|\overline{\vec{\tau}}\right|_{\mathrm{neu}}} - 1 \right) \times 100 \qquad 5$$

where $\left|\overline{\vec{\tau}}\right|_{\mathrm{var}}$ is the magnitude of the monthly mean surface wind stress calculated using a drag coefficient which varies with stability, and $\left|\overline{\vec{\tau}}\right|_{\mathrm{neu}}$ is the magnitude of the monthly mean surface wind stress computed with a constant (neutral) coefficient. A value of $R = 0.0$ corresponds to neutrally stable conditions.

The ratio defined by Equation (5) is displayed in Figures 5 and 6 for the months of June and December, respectively. The average percentage difference is between 2 and 5%. Values greater than 10% are rare. In December, the values are positive, indicating unstable conditions. Negative values occur in June. These are related to the stable stratification induced by positive air-sea temperature differences within the coastal upwelling zone. The effects of atmospheric stability determined in this study are less than the values of 6 to 15% reported by Husby and Seckel (1975) for Ocean Weather Station "Victor," but consistent with the values of less than 5% reported by Dorman et al. (1974) for Ocean Weather Station "November."

WIND STRESS DISTRIBUTIONS

The long-term composite monthly mean fields of surface wind stress are displayed in Appendix I as resultant vectors (Charts 1 to 12), east components (Charts 13 to 24), and north components (Charts 25 to 36). These data indicate two characteristic features. The mean stress tends to be directed equatorward along the coast from Cape Mendocino to Baja California throughout the year. Off the coasts of Oregon and Washington, the wind stress exhibits marked seasonal variability in both magnitude and direction.

The distributions of surface wind stress off Baja California have been previously discussed by Bakun and Nelson (1975).[4] They concluded that most of the seasonal variability is in magnitude rather than direction. The mean surface wind stress tends to have an alongshore, equatorward component during all months, implying conditions generally favorable for coastal upwelling throughout the year. This is contrasted with the situation to the north. Off the coasts of Oregon and Washington, patterns of surface wind stress change seasonally. From December to February, the stress impinges on the coast at Cape Blanco, forming the southern boundary of the low pressure system which develops in the Gulf of Alaska during the winter. From May through September, the surface wind stress veers toward the south. The components are directed onshore and equatorward. The months of March-April and October-November appear as transition periods. The surface wind stress is directed primarily onshore off Washington and Oregon during these months.

The most evident feature in these distributions is the position and extent of the predominant wind stress maximum. For purposes of discussion, this maximum is defined by the 1.0 dyne cm^{-2} contour and is highlighted by light shading in Charts 1 to 12. Large values of stress occurring between lat. 45°N and 50°N during winter are probably associated with either high winds or sparse data, and will be ignored in this discussion.

The maximum is first evident in March, south of Point Conception. During succeeding months, the maximum strengthens, increases in size, and shifts northward. In April, values exceeding 1.0 dyne cm^{-2} cover an area from Point Conception to San Francisco. Winds off Oregon have veered, suggesting an alongshore component and implying conditions generally favorable for coastal upwelling. The pattern of surface wind stress is repeated in May. The northern boundary of the central maximum reaches the coast south of Cape Blanco.

The mean wind stress reaches maximum intensity during June and July off Cape Mendocino, where characteristic values exceed 1.5 dynes cm^{-2}. The large-scale maximum extends approximately 500 km in the offshore direction and 1,000 km in the longshore direction. A more intense coastal maximum ($\left|\overline{\vec{\tau}}\right| \geq 1.5$ dynes cm^{-2}) is coherent over an area approximately one-fifth this size. Maximum values of mean surface wind stress typically occur 200 to 300 km off the coast, rather than adjacent to the coast. This feature was previously observed by Munk (1950) and Reid et al. (1958). Mean distributions for August and September suggest relaxing conditions; the maximum is reduced in extent and intensity. These months still exhibit a degree of equatorward stress along the coasts of Oregon and Washington, but in October, the direction backs to the north. The poleward components correspond to onshore Ekman transport and subsequent downwelling at the coast. The distributions for November, December, January, and February indicate characteristic winter conditions. Mean values are typically less than 0.5 dyne cm^{-2}. High winds associated with intense storm activity in the North Pacific Ocean result in regions of mean surface wind stress exceeding 1.0 dyne cm^{-2} off the coasts of Oregon and Washington.

Seasonality of the surface wind stress and its association with coastal upwelling are easily observed along the northern section of the grid. Large changes in mean direction are apparent. Maximum magnitudes occur during the winter. Winds favorable for coastal upwelling occur from April to September. During the remaining months, the direction of the mean surface wind stress corresponds to downwelling at the coast.

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[4] Bakun, A. and C. S. Nelson, 1975. Climatology of upwelling-related processes off Baja California. Unpubl. manuscr., 41 p. On file at Pacific Environmental Group, National Marine Fisheries Service, NOAA, Monterey, CA 93940.

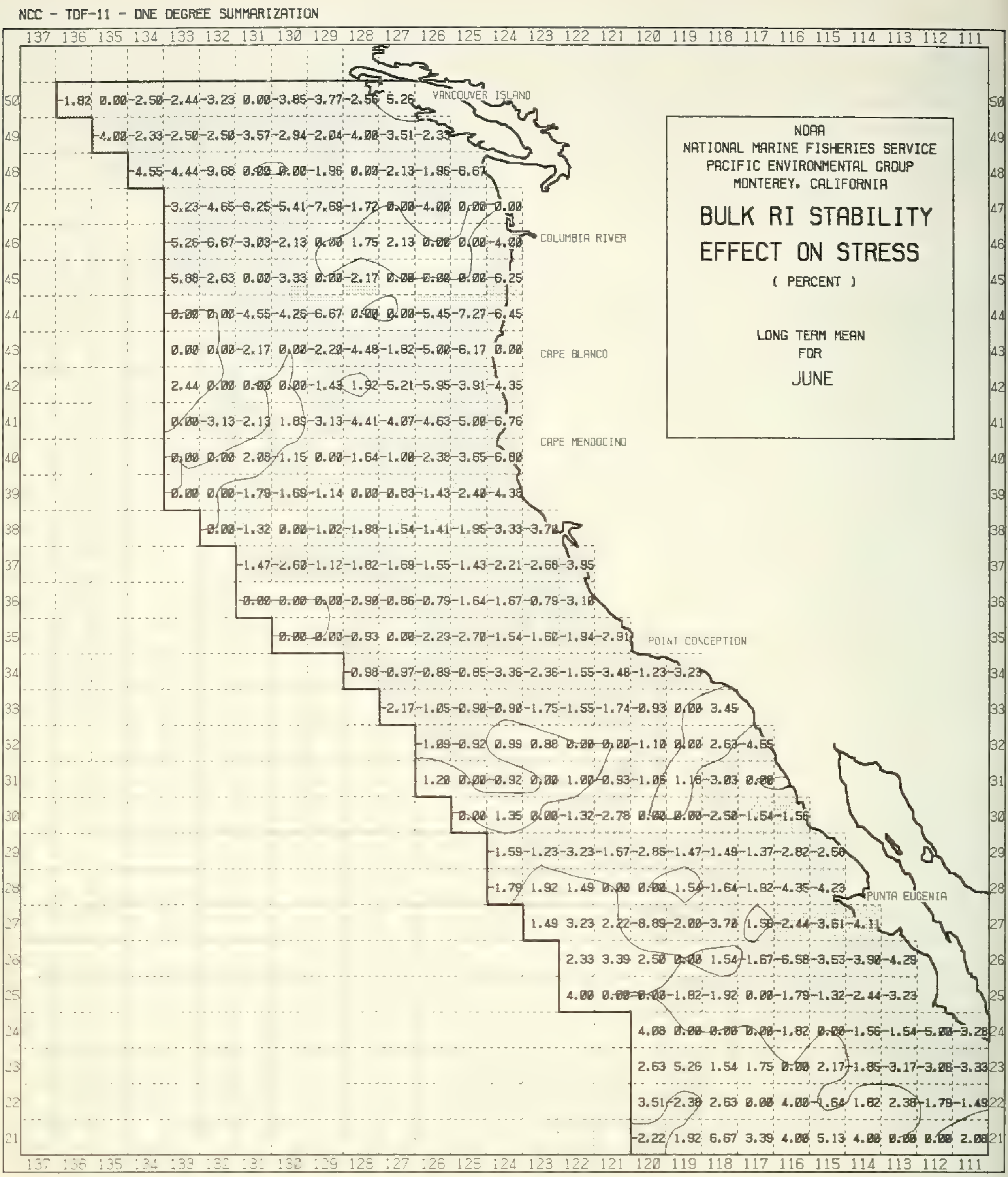

Figure 5.—The effect of atmospheric stability on surface wind stress for June. Plotted values are the percentage increase (decrease) in the surface wind stress above (below) neutrally stable conditions. The contour interval is 10.0. Positive values correspond to unstable conditions. Negative values are shaded.

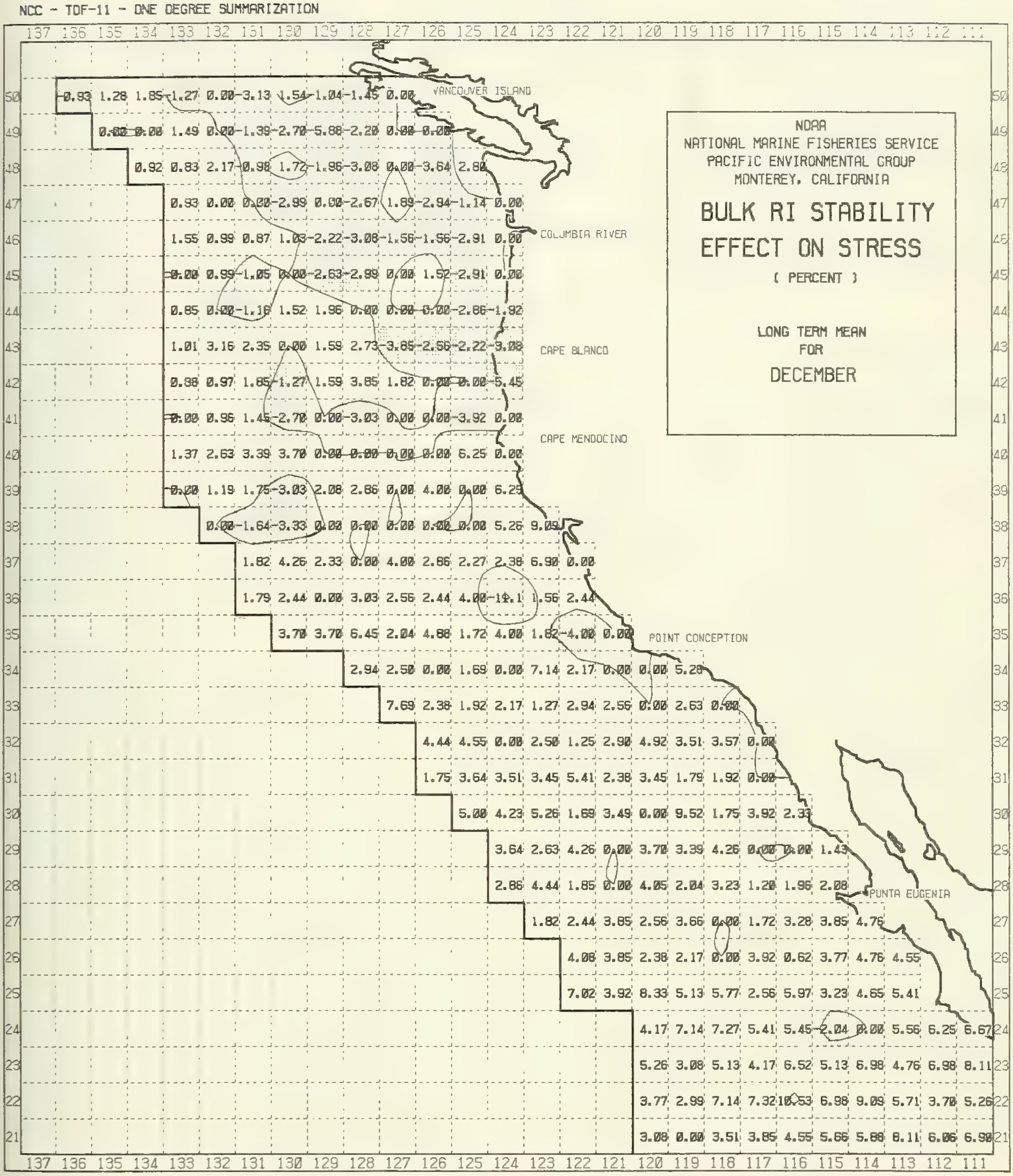

Figure 6.—The effect of atmospheric stability on surface wind stress for December. Plotted values are the percentage increase (decrease) in the surface wind stress above (below) neutrally stable conditions. The contour interval is 10.0. Positive values correspond to unstable conditions. Negative values are shaded.

The coast along southern California and Baja California is characterized by winds favorable for upwelling throughout the year. Peak values of surface wind stress occur in April and May. Values exceeding 0.5 dyne cm^{-2} are evident from February to July. A local maximum immediately north of Punta Eugenia is easily observed in May. This feature is consistent throughout the year. A region of local wind stress minima is indicated along the coast south of Point Conception. This feature corresponds in location with the semipermanent cyclonic eddy which dominates the ocean surface circulation in the Southern California Bight (Reid et al. 1958).

Spatial and Temporal Variability

Spatial and seasonal variability of the monthly distributions will be described in terms of standard errors of the means (Equation (3)), constancy of the wind stress, and frequency diagrams for selected 1-degree square areas and months. In general, these data indicate greater variability in magnitude and direction in the region north of Cape Mendocino than in the area to the south. Summer distributions are characterized by well-defined mean directions and magnitudes. Broad-banded frequency histograms are typical of winter months.

The degree of variability in direction and magnitude of the surface wind stress is reflected in the spatial distributions of the standard errors of the means. In regions outside of the primary shipping lanes (see Fig. 2), monthly mean distributions are based on approximately the same number of observations per 1-degree square area. If one assumes that there are no systematic sampling errors in these regions, then the magnitudes of the computed standard errors of the means should be a function of the wind stress variability. Accordingly, standard errors to the north of Cape Mendocino are larger by a factor of 2 to 3 (Appendix II) than those to the south of Cape Mendocino. Thus, the data imply a greater degree of variation in the direction and magnitude of the surface wind stress off Oregon and Washington than off California.

A contrast between winter and summer conditions is also evident. South of Cape Mendocino, magnitudes of the standard errors of the means remain nearly constant throughout the year. Off Oregon and Washington, the computed values decrease to a minimum during the summer, and increase to a maximum during the winter. Typical values range from 0.10 dyne cm^{-2} in June to 0.30 dyne cm^{-2} in December.

Similar features of the large-scale temporal and spatial variations are evident in monthly distributions of constancy of the wind stress as defined by the ratio of the magnitude of the average stress to the average magnitude of the stress. Figures 7 and 8 show the patterns for June and December. During December, values greater than 0.5 occur south of Point Conception. To the north, wind stress constancy decreases to relatively small values, implying a high degree of directional variability. An increase in directional constancy is indicated during June. Values greater than 0.50 extend from Baja California to Vancouver Island. Values less than 0.50 occur only in the northwest section of the grid. South of Cape Mendocino, the ratios approach a value of 1.0, implying very little variation in wind stress direction.

The patterns of wind stress constancy indicate possible error in estimates of the total mechnical energy transfer at the air-sea interface. In the region off California, the magnitude of the mean vector wind stress appears to be a good estimator of the total stress acting on the sea surface. However, in the northern regions of the data grid, these data show that the magnitude of the mean vector wind stress underestimates the total stress acting on the sea surface. This has important implications for mixed-layer modelling, in which the input of turbulent energy depends on the total stress acting on the sea surface (Denman 1973), the direction of the surface stress, and the rate at which the stress is applied to the sea surface (Niiler 1975).

The large-scale spatial and temporal variations in surface wind stress distributions are finally described in terms of selected frequency diagrams. Data for the 10 squares indicated in Figure 1 are displayed in Figures 9 to 12. Figures 9 and 10 show data for June and December taken from the five squares indicated in the inset. Similar data at five different locations are presented for July and January in Figures 11 and 12.[5]

Available wind stress data have been classed by direction and magnitude for each 1-degree square area and month. Relative frequencies have been determined for 16 direction bands and for 11 magnitude bands. A category for calm winds also includes variable winds. The direction bands are 22.5° wide and the magnitude bands correspond to equivalent wind speed intervals of 2.0 m s^{-1}.

The relative frequency surfaces shown in these figures display contours of percentage of total reports falling within a given direction and magnitude band. The 2.5% and 7.5% contours are indicated by a solid line. Dashed line contours indicate relative frequencies of 5.0% and 10.0%. The mean vector magnitude and direction is indicated by an arrow. Note that directions are defined with the oceanographic convention (i.e., the direction toward which the wind blows).

The histograms shown to the right of each frequency surface display relative frequencies for magnitude at the top, and direction at the bottom. Relative percent is labelled along the ordinate. Midpoints of the magnitude and direction class intervals are labelled on the abscissa.

The contrast between winter and summer distributions in the southern section of the grid appears as a change in the character of the frequency surfaces (Figs. 9, 10). In general, the number of contours indicated for June is greater than the number of contours appearing in December. Evidently, the wind stress is relatively constant in magnitude and direction during the summer

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[5] Wind roses for all 1-degree squares within the area north of lat. 34°N may be found in *Climatic study of the near coastal zone; West Coast of the United States*, published by the Director, Naval Oceanography and Meteorology, June 1976, 133 p.

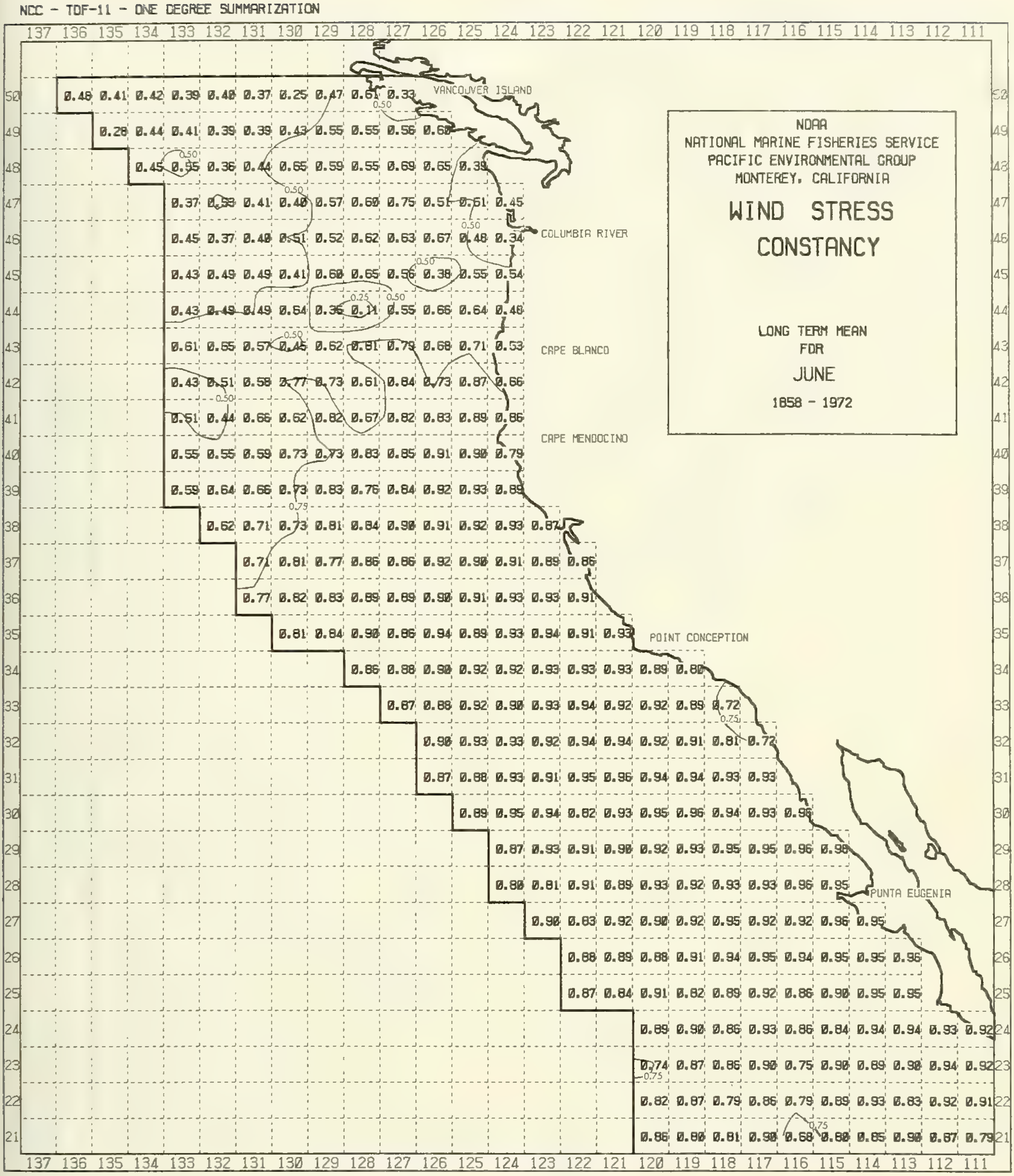


Figure 7.—Wind stress constancy for June. The plotted values are defined as the ratios of the vector means to the scalar means. The contour interval is 0.25.

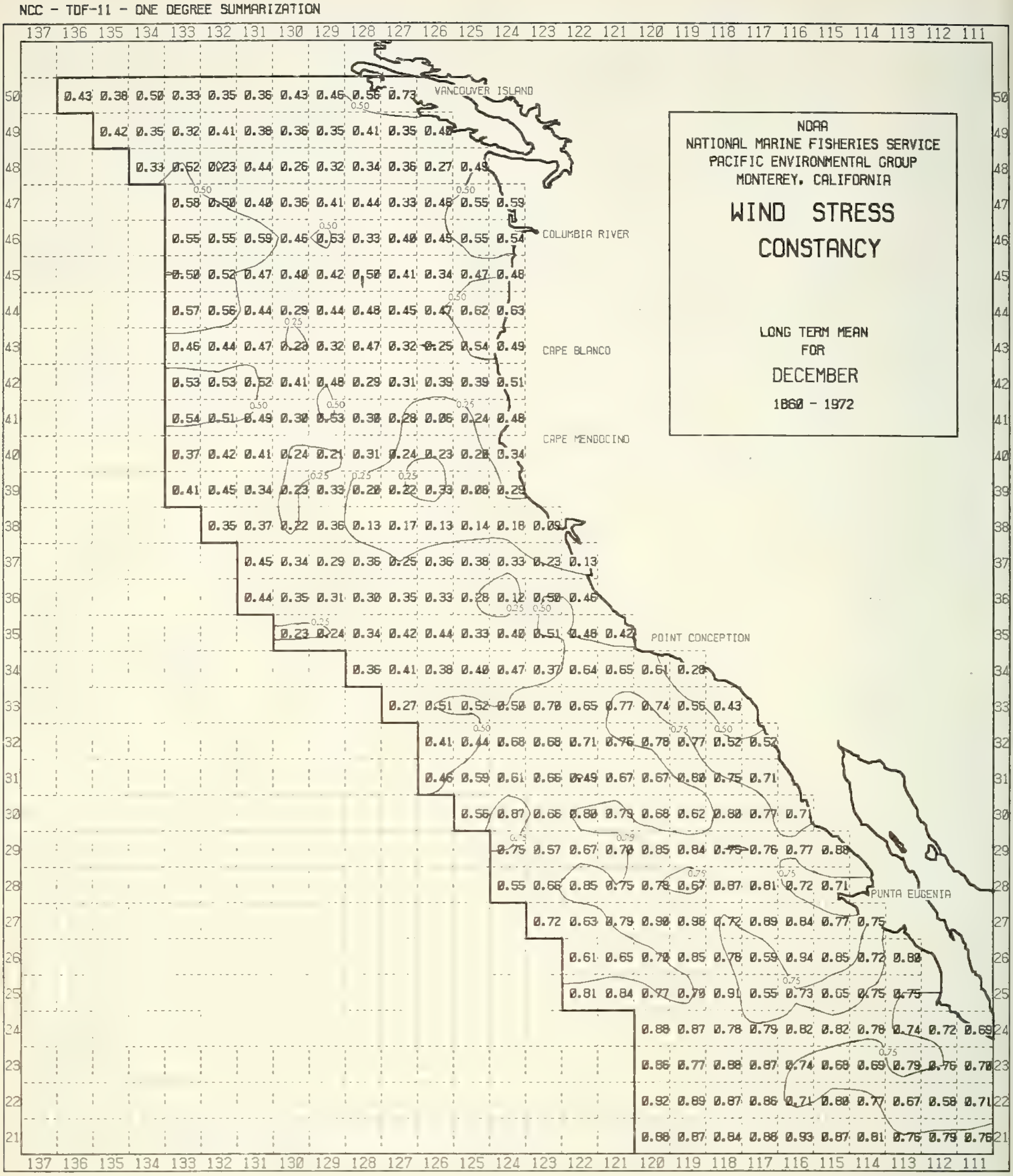


Figure 8.—Wind stress constancy for December. The plotted values are defined as the ratios of the vector means to the scalar means. The contour interval is 0.25.

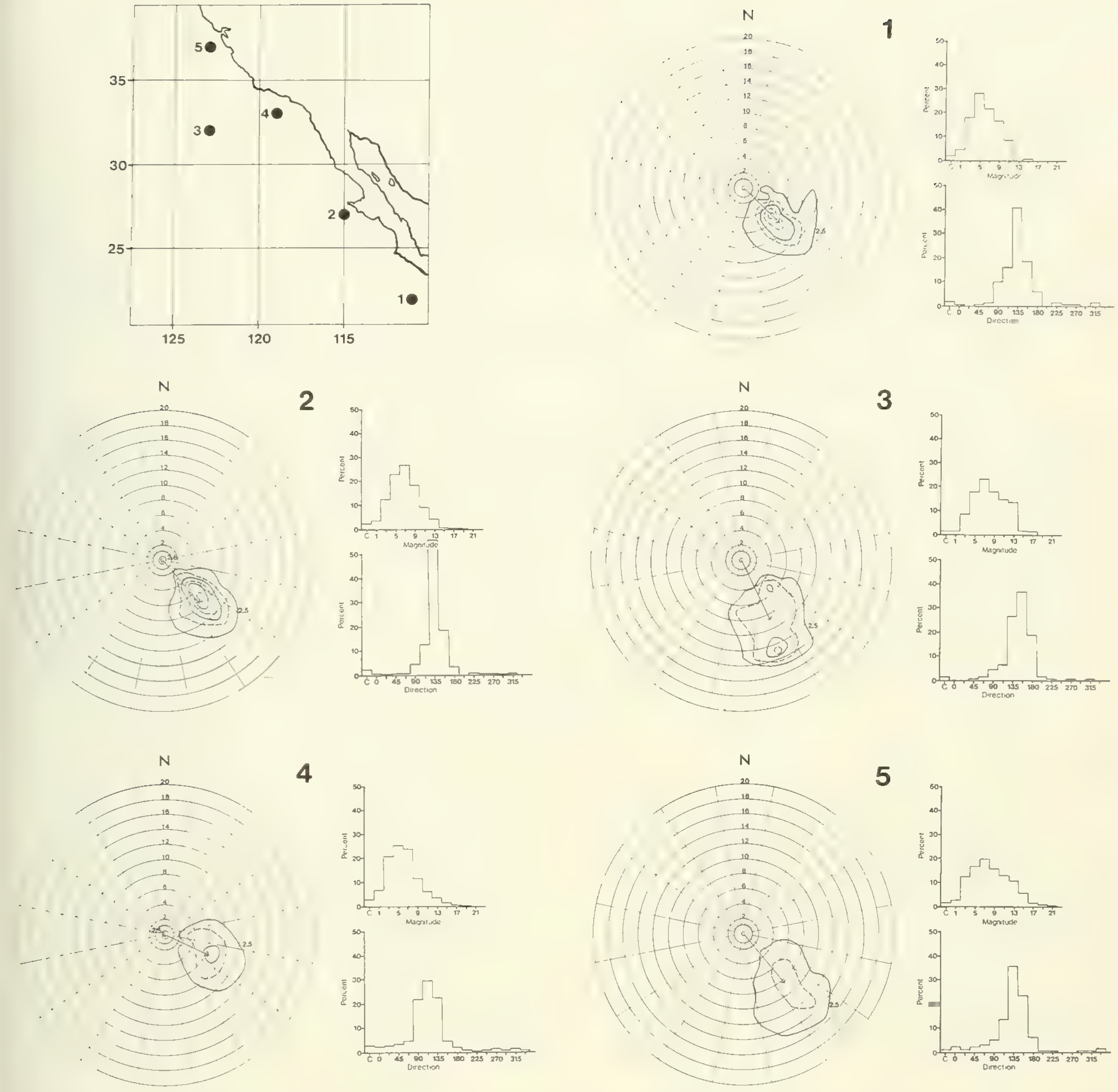


Figure 9.—Relative frequency surfaces and frequency histograms for June. Data are shown for the 1-degree squares labelled 1 through 5 in the upper left inset. Contours of relative frequency are drawn at intervals of 2.5%. Mean vector wind stress is indicated by an arrow.

months. A slight shift in direction and magnitude of the wind stress is indicated between summer and winter. The mean stress in December is directed more toward the south, and the magnitude has decreased.

The frequency histograms also show these features. During June, the direction histogram is characteristically narrow-banded. Over 70% of the observations may be concentrated within three direction intervals. In December, the observations tend to be spread over a wider range of directions. The histograms are broader and the peaks in direction are less well-defined. Peak magnitudes in June are generally one class interval larger than peak magnitudes in December. However, the winter distributions are characterized by an increase in relative frequency at high values of wind stress magnitude.

A similar pattern of contrasts between summer and winter distributions is apparent in the northern section of the grid. As shown in Figures 11 and 12, the direction histograms are generally well-defined during the summer, although bimodal distributions are evident. During winter, observations are nearly uniformly spread among all directions. There is a lack of consistency in the frequency surfaces in Figure 12. Direction histograms for

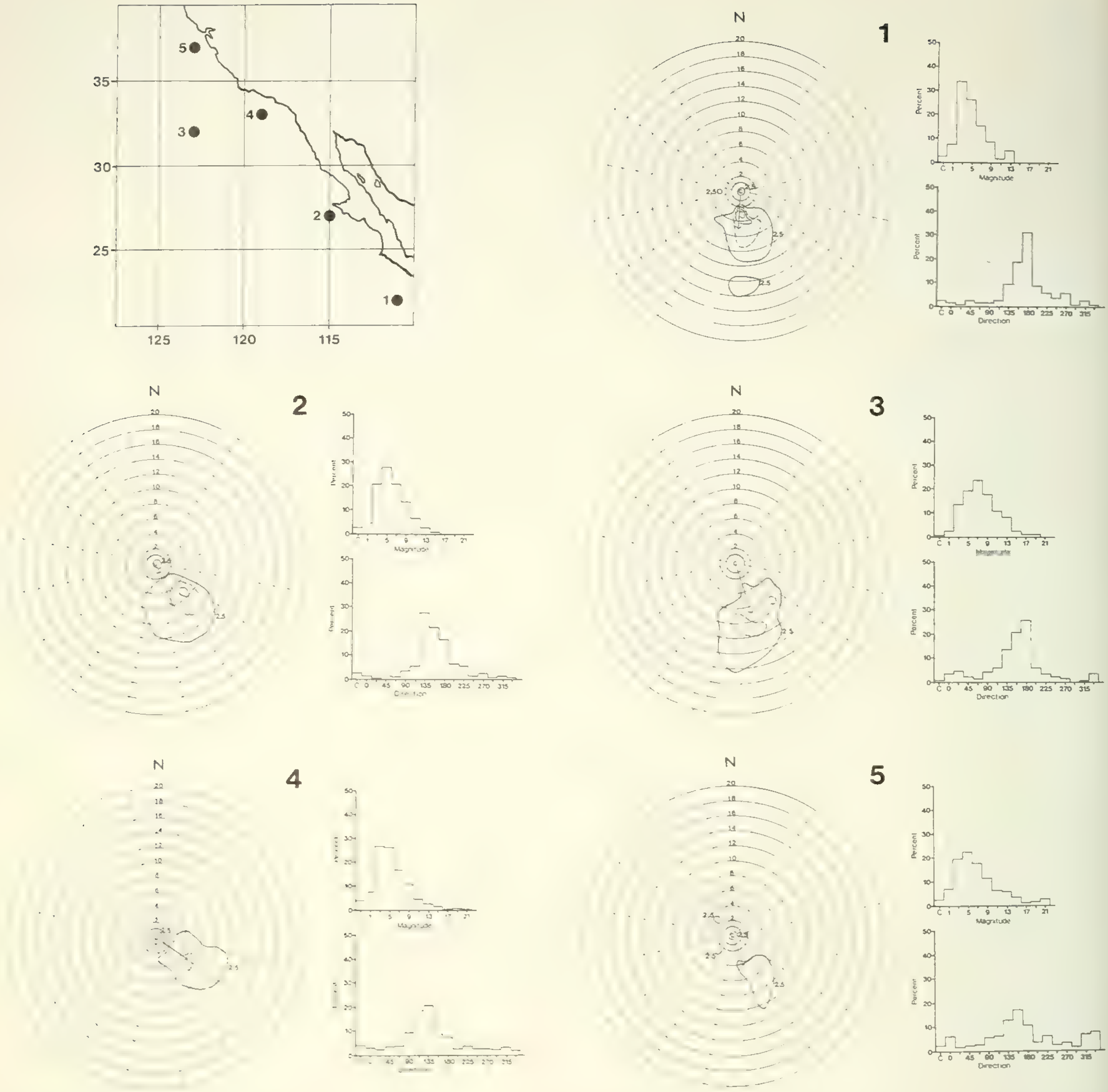


Figure 10.—Relative frequency surfaces and frequency histograms for December. Data are shown for the 1-degree squares labelled 1 through 5 in the upper left inset. Contours of relative frequency are drawn at intervals of 2.5%. Mean vector wind stress is indicated by an arrow.

January are broad and flat and the peaks which generally characterize the summer distributions are missing. Mean directions shift from equatorward to poleward between summer and winter. A complete reversal in the mean direction occurs at point 7 (Figs. 11, 12). A shift in magnitude is equally pronounced. Peak magnitudes are higher in January than in July indicating a greater contribution of high wind speeds in January.

The above discussion adds a new dimension to the seasonal descriptions of the surface wind stress distributions over the California Current. Pronounced seasonal variations in magnitude and direction of the monthly mean wind stress are indicated along the entire west coast of the United States. These changes are most evident off the coasts of Oregon and Washington. In addition, these data suggest month to month changes in the large-scale spatial variability. Frequency histograms for direction and magnitude are broad and flat during the winter months, and along the northern coast. Well-defined peaks in magnitude and direction characterize the distributions during the summer and along the southern coast.

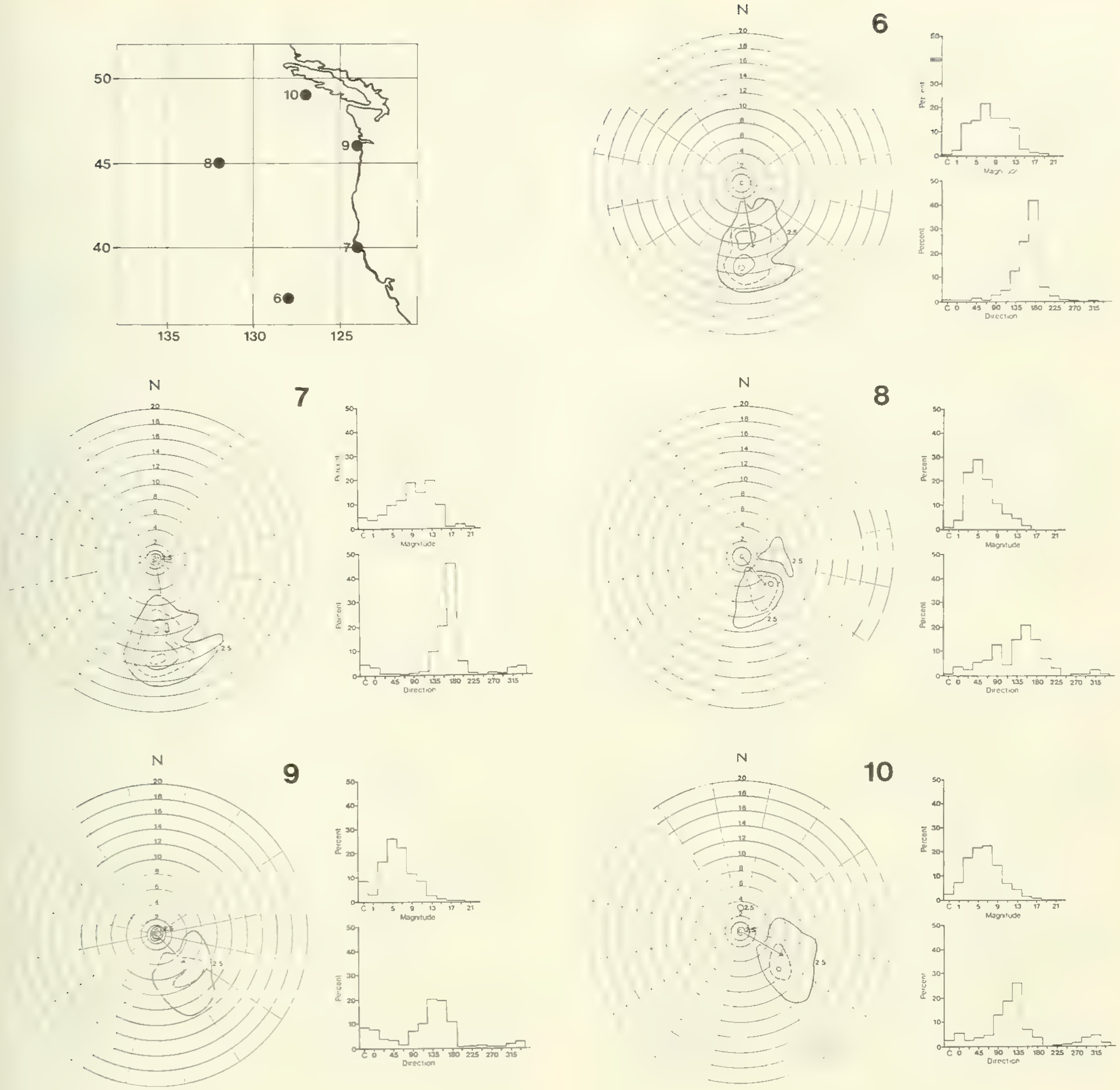


Figure 11.—Relative frequency surfaces and frequency histograms for July. Data are shown for the 1-degree squares labelled 6 through 10 in the upper left inset. Contours of relative frequency are drawn at intervals of 2.5%. Mean vector wind stress is indicated by an arrow.

Seasonal Cycle at the Coast

Time series of the surface wind stress within the 1-degree square areas immediately adjacent to the coast are displayed in Figure 13 as the alongshore component, and in Figure 14 as the onshore component. For these displays, the vector means have been resolved into components parallel and perpendicular to the coast. The coastline angles were determined by visually fitting a line to the dominant trend of the coast within each 1-degree square. The months are indicated along the tops of the figures. The latitudes of the 1-degree squares are indicated on the right and left sides of the figures. Negative values are shaded and indicate equatorward alongshore stress in Figure 13 and offshore stress in Figure 14.

Several characteristic features are apparent in these figures. South of lat. 40°N there is an equatorward component throughout the year, implying conditions favorable for coastal upwelling in all months. Off the coasts of Oregon and Washington, the data suggest that upwelling occurs seasonally between the months of April and September.

Three relative maxima occur in the time/space domain. Off the coast of Baja California, maximum values

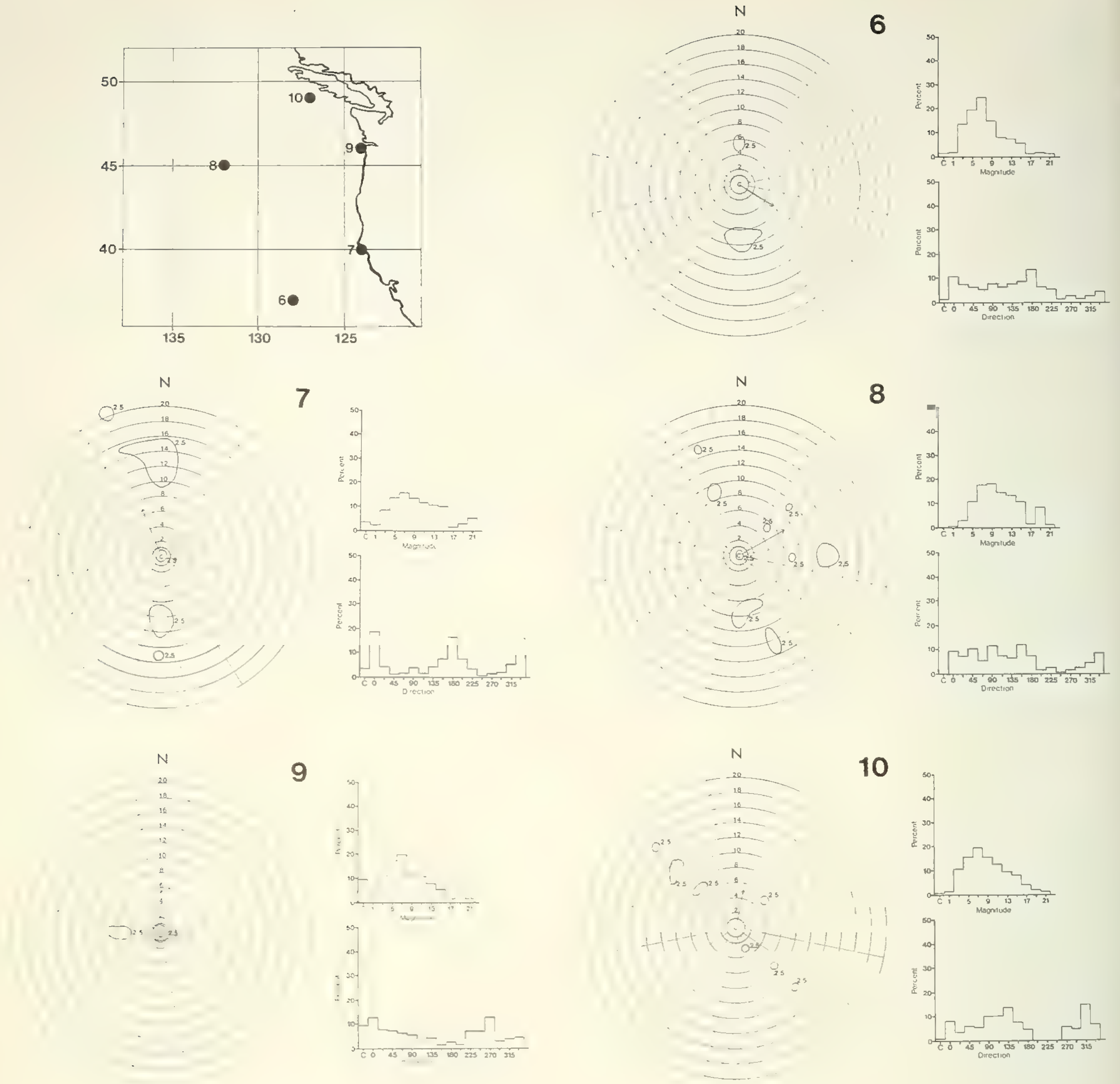
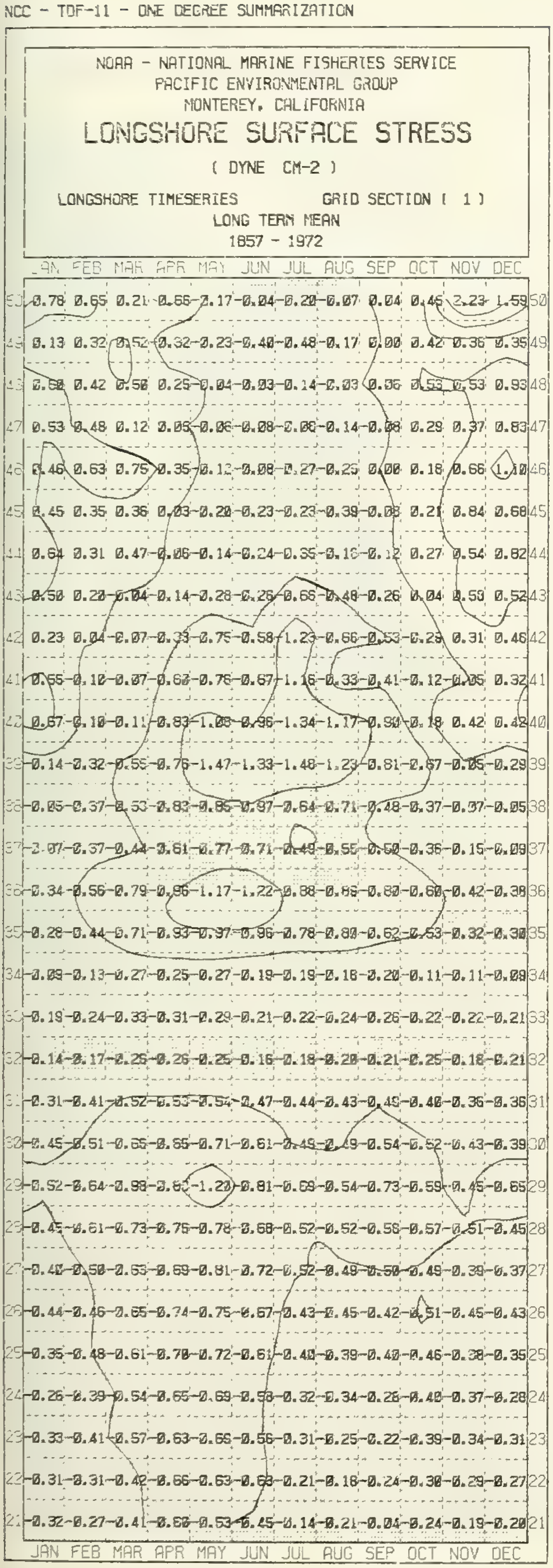


Figure 12.—Relative frequency surfaces and frequency histograms for January. Data are shown for the 1-degree squares labelled 6 through 10 in the upper left inset. Contours of relative frequency are drawn at intervals of 2.5%. Mean vector wind stress is indicated by an arrow.

of wind stress are evident near Punta Eugenia in May. A large maximum occurs just south of Cape Mendocino between May and August. A smaller, local maximum occurs in May and June at lat. 36°N.

Figure 13 is similar in appearance to a time series of offshore Ekman transport shown by Bakun et al. (1974). They showed a good correlation between the occurrence of maximum offshore transport at lat. 39°N and a suppression of seasonal warming in the adjacent coastal waters during early summer, which is indicative of upwelling. The timing of the central wind stress maximum off the coast from Cape Mendocino agrees with the description of the mean yearly cycle of indicated upwelling given by Bakun (1973). However, Bakun's data are spatially distorted, and indicate maximum values at lat. 33°N, long. 119°W in the middle of the Southern California Bight. The spatial distortion is primarily caused by development of an intense thermal low over southern California during the summer. The influence of this low pressure system, and the effects of coastal mountain ranges distort the analyzed pressure fields used in Bakun's computations.

The time series of alongshore surface wind stress (Fig. 13) suggests a slight tilt, with time and space, to the region of maximum values. This corresponds to a northward shift in the intensity of the surface wind stress from



April and May off the coast of Baja California to June, July, and August off Cape Mendocino and Cape Blanco.

Figure 14 indicates a tendency for the surface wind stress to be directed onshore throughout the year north of lat. 30°N. Off the coast of Baja California, surface stress is characterized by offshore components, except between the months of April and October. Offshore components are also apparent in the vicinity of Cape Mendocino and Point Conception. Near these points, abrupt changes in coastline orientation may influence the direction and magnitude of the surface wind stress.

WIND STRESS CURL

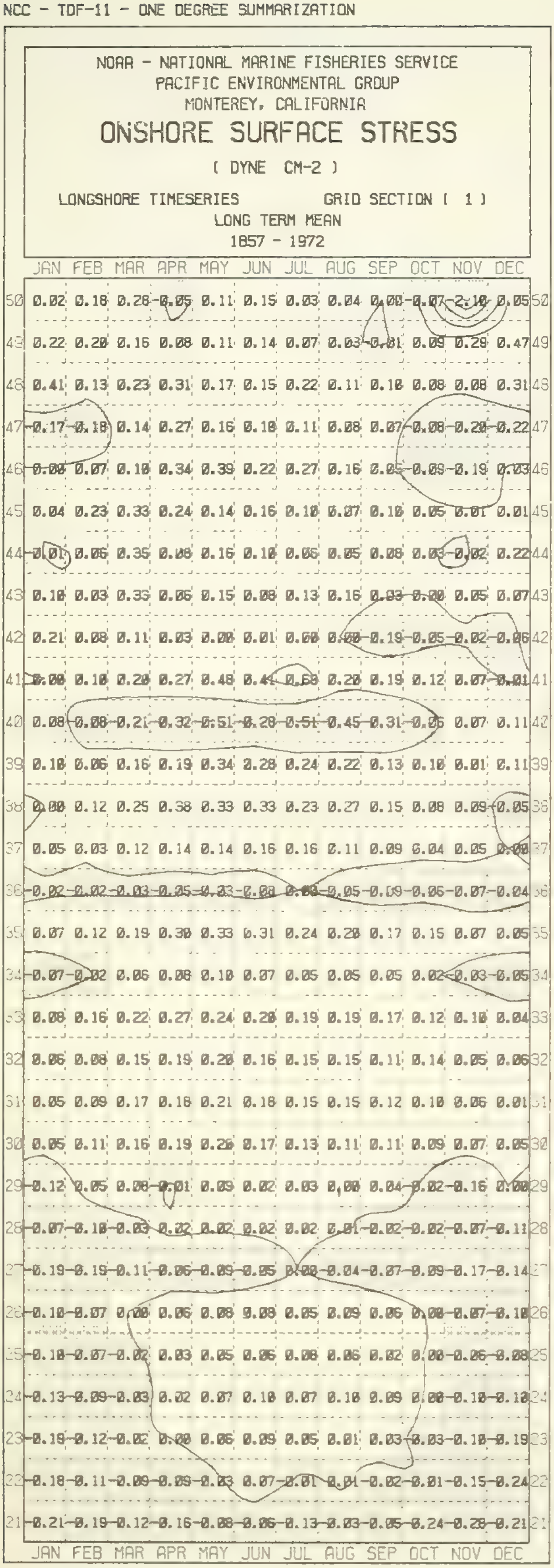
The surface wind stress curl is the forcing function for the vertically integrated mass transport of the wind-driven ocean circulation. Under linear, steady-state conditions on the "β-plane," in the absence of friction and interactions with bottom topography, the meridional component of mass transport (M_y) is directly proportional to the vertical component of the curl of the wind stress as expressed in Equation (6):

$$M_y = \frac{\vec{k} \cdot (\nabla \times \vec{\tau})}{\beta} \qquad (6)$$

where M_y is the meridional component of the vertically integrated mass transport, β is the meridional derivative of the Coriolis parameter f, and $\vec{k} \cdot (\nabla \times \vec{\tau})$ is the vertical component of the wind stress curl. According to the simplified model, positive (negative) wind stress curl is associated with northward (southward) meridional transport. Surface Ekman divergence (convergence) corresponding to positive (negative) wind stress curl is balanced by geostrophic convergence (divergence) in the northward (southward) meridional flow.

Coastal upwelling occurs only at the ocean boundary. However, wind induced upwelling will occur whenever divergence in the surface wind drift is not balanced by other modes of horizontal surface flow. Figure 15 shows a mechanism by which the wind stress curl determines the divergent or convergent nature of the surface wind drift offshore of the primary coastal upwelling zone. A seaward increase in the equatorward wind stress parallel to the coast (Fig. 15A) is characterized by positive wind stress curl. In this situation, the offshore component of Ekman transport increases in the offshore direction, resulting in continued surface divergence. Upwelling is required to maintain the mass balance. If the equatorward longshore surface wind stress decreases in the offshore direction (Fig. 15B), the wind stress curl is negative. Convergence in the surface wind drift will result. Frontal formation and downwelling may occur just offshore of the primary coastal upwelling zone.

Figure 13.—Seasonal cycle of alongshore surface wind stress near the coast. Means of the alongshore components of wind stress were computed by month for the 1-degree squares immediately adjacent to the coast. Units are dyne cm^{-2}. The contour interval is 0.5 dyne cm^{-2}. Equatorward alongshore stress is shaded. Numbers along ordinate are degrees north latitude.



NCC - TDF-11 - ONE DEGREE SUMMARIZATION

NOAA - NATIONAL MARINE FISHERIES SERVICE
PACIFIC ENVIRONMENTAL GROUP
MONTEREY, CALIFORNIA
ONSHORE SURFACE STRESS
(DYNE CM-2)
LONGSHORE TIMESERIES GRID SECTION (1)
LONG TERM MEAN
1857 - 1972

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
50	0.02	0.18	0.28	-0.05	0.11	0.15	0.03	0.04	0.00	-0.07	-2.10	0.05	50
49	0.22	0.20	0.16	0.08	0.11	0.14	0.07	0.03	-0.01	0.09	0.29	0.47	49
48	0.41	0.13	0.23	0.31	0.17	0.15	0.22	0.11	0.10	0.08	0.08	0.31	48
47	-0.17	-0.18	0.14	0.27	0.16	0.10	0.11	0.08	0.07	-0.08	-0.20	-0.22	47
46	-0.00	0.07	0.10	0.34	0.39	0.22	0.27	0.16	0.05	-0.09	-0.19	0.03	46
45	0.04	0.23	0.33	0.24	0.14	0.16	0.10	0.07	0.10	0.05	0.01	0.01	45
44	-0.01	0.06	0.35	0.08	0.16	0.10	0.06	0.05	0.08	0.03	-0.02	0.22	44
43	0.10	0.03	0.33	0.06	0.15	0.08	0.13	0.16	0.03	-0.00	0.05	0.07	43
42	0.21	0.08	0.11	0.03	0.00	0.01	0.00	0.00	-0.19	-0.05	-0.02	-0.06	42
41	0.00	0.10	0.20	0.27	0.48	0.44	0.60	0.20	0.19	0.12	0.07	-0.01	41
40	0.08	-0.08	-0.21	-0.32	-0.51	-0.20	-0.51	-0.45	-0.31	-0.26	0.07	0.11	40
39	0.10	0.06	0.16	0.19	0.34	0.28	0.24	0.22	0.13	0.10	0.01	0.11	39
38	0.00	0.12	0.25	0.38	0.33	0.33	0.23	0.27	0.15	0.08	0.09	-0.05	38
37	0.05	0.03	0.12	0.14	0.14	0.16	0.16	0.11	0.09	0.04	0.05	0.00	37
36	-0.02	-0.02	-0.03	-0.05	-0.03	-0.08	0.00	-0.05	-0.09	-0.06	-0.07	-0.04	36
35	0.07	0.12	0.19	0.30	0.33	0.31	0.24	0.20	0.17	0.15	0.07	0.05	35
34	-0.07	-0.02	0.06	0.08	0.10	0.07	0.05	0.05	0.05	0.02	-0.03	-0.05	34
33	0.08	0.16	0.22	0.27	0.24	0.20	0.19	0.19	0.17	0.12	0.10	0.04	33
32	0.06	0.08	0.15	0.19	0.20	0.16	0.15	0.15	0.11	0.14	0.05	0.06	32
31	0.05	0.09	0.17	0.18	0.21	0.18	0.15	0.15	0.12	0.10	0.06	0.01	31
30	0.05	0.11	0.16	0.19	0.26	0.17	0.13	0.11	0.11	0.09	0.07	0.05	30
29	-0.12	0.05	0.08	-0.01	0.09	0.02	0.03	0.00	0.04	-0.02	-0.16	0.00	29
28	-0.07	-0.10	-0.03	0.22	0.02	0.02	0.02	0.01	-0.02	-0.02	-0.07	-0.11	28
27	-0.19	-0.19	-0.11	-0.06	-0.09	-0.05	0.00	-0.04	-0.07	-0.09	-0.17	-0.14	27
26	-0.10	-0.07	0.00	0.06	0.08	0.08	0.05	0.09	0.06	0.00	-0.07	-0.10	26
25	-0.10	-0.07	-0.02	0.03	0.05	0.06	0.08	0.06	0.02	0.00	-0.06	-0.08	25
24	-0.13	-0.09	-0.03	0.02	0.07	0.10	0.07	0.10	0.09	0.00	-0.10	-0.10	24
23	-0.19	-0.12	-0.02	0.00	0.06	0.09	0.05	0.01	0.03	-0.03	-0.10	-0.19	23
22	-0.18	-0.11	-0.09	-0.09	-0.03	0.07	-0.01	0.01	-0.02	-0.01	-0.15	-0.24	22
21	-0.21	-0.19	-0.12	-0.16	-0.08	-0.06	-0.13	-0.03	-0.05	-0.24	-0.28	-0.21	21
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	

Figure 14.—Seasonal cycle of onshore surface wind stress near the coast. Means of the onshore components of wind stress were computed by month for the 1-degree squares immediately adjacent to the coast. Units are dyne cm^{-2}. The contour interval is 0.5 dyne cm^{-2}. Offshore stress is shaded. Numbers along ordinate are degrees north latitude.

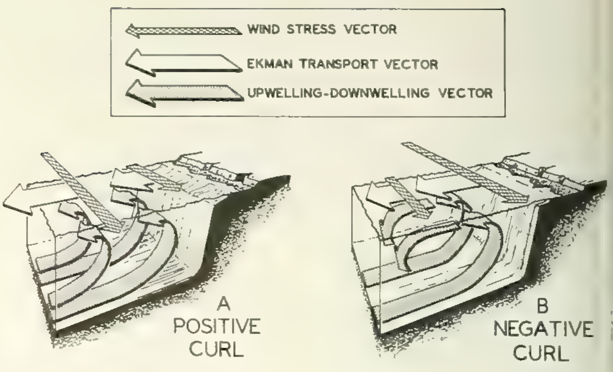


Figure 15.—A conceptual diagram of the relationship of wind stress curl to the divergence and convergence of surface Ekman transport offshore of the primary coastal upwelling zone.

Direct measurements of wind stress curl are not available; however, the curl of the monthly mean surface wind stress fields has been computed. The vertical component of the curl of the wind stress in spherical coordinates is defined by:

$$\vec{k}\cdot(\nabla\times\overline{\vec{\tau}}) = \frac{1}{R\cos\varphi}\left[\frac{\partial\bar{\tau}_y}{\partial\lambda} - \frac{\partial}{\partial\varphi}(\bar{\tau}_x\cos\varphi)\right] \qquad (7)$$

where R is the radius of the earth, φ and λ denote geographic latitude and longitude, respectively, and $\bar{\tau}_x$ and $\bar{\tau}_y$ denote the eastward and northward components of the mean surface wind stress. A finite difference equation approximating the curl at the grid point (i, j) in Figure 16 is given by:

$$\vec{k}\cdot(\nabla\times\overline{\vec{\tau}}_{i,j}) = \frac{1}{R\cos\varphi_i}\left[\frac{\bar{\tau}_{y_{i+1,j}}-\bar{\tau}_{y_{i-1,j}}}{2\Delta\lambda} - \left(\frac{(\bar{\tau}_x\cos\varphi)_{i,j+1}-(\bar{\tau}_x\cos\varphi)_{i,j-1}}{2\Delta\varphi}\right)\right] \qquad (8)$$

where $\Delta\varphi = \Delta\lambda = 1°$. The method is similar to calculations described by Hantel (1970). Centered differences were utilized throughout the interior of the data grid. Forward and backward differences were required along the boundaries. As a result, certain artificial features may have been introduced at these boundaries.

Monthly Curl Distributions

Monthly fields of surface wind stress curl are displayed in Appendix III (Charts 37 to 48). These distributions correspond to the monthly mean wind stress distributions shown in Appendix I. Values are plotted in units of dyne cm^{-2} per 100 km. A value of 1 dyne cm^{-2}

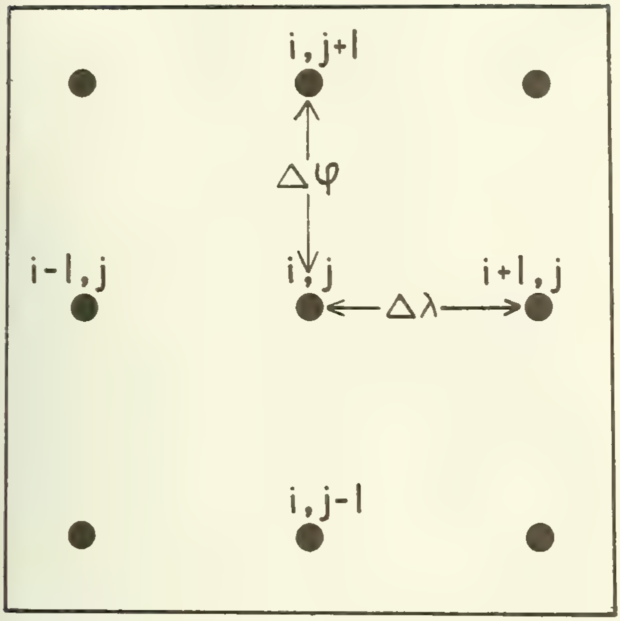


Figure 16.—Discretization grid used in calculating the wind stress curl.

per 100 km is equivalent to 1×10^{-7} dyne cm^{-3}. Negative values of wind stress curl are shaded.

Small scale features evident in these distributions should be viewed with caution. Detail within a single 1-degree square area which is not supported by similar values in surrounding squares probably reflects "noise" in the monthly means of surface wind stress. Objective smoothing procedures applied to the monthly mean wind stress fields would result in more homogeneous distributions of wind stress curl. A particular method has been described by Evenson and Veronis (1975).

Characteristic absolute magnitudes of the spatially averaged wind stress curl are 1×10^{-8} dyne cm^{-3}. This value is approximately a factor of two less than the summertime mean reported by Halpern (1976) for an upwelling region near the Oregon coast. Considering the time and space averages used in the present study, this difference appears to be reasonable. However, the values are consistent with wind stress curl calculations reported by Saunders (1976). The probable errors associated with these estimates of wind stress curl may be calculated from a knowledge of the spatial distributions of standard errors of the (wind stress) component means (see Appendix II). On average, the expected error is 1×10^{-8} dyne cm^{-3}, with maximum and minimum errors of 4×10^{-8} dyne cm^{-3} and 1×10^{-10} dyne cm^{-3}, respectively. Of course, these values apply to particular individual 1-degree squares. Large values generally correspond to "holes" in the distributions, which are easily seen in the monthly charts. For larger space scales, errors associated with the gradients of the mean wind stress components would tend to cancel. Thus, greater confidence may be expected for the patterns of wind stress curl which are consistent over several degrees of latitude and longitude.

The large-scale features of positive and negative curl along the coast are significant. Important details to note are the sign of the wind stress curl at the coast, and the position of the line of zero wind stress curl. A general feature common to all months is the occurrence, on average, of positive wind stress curl near the coast, and negative curl at some distance offshore. This feature is well developed from May to September. Greater spatial variability is evident in winter distributions.

Existence of an offshore wind stress maximum results in a line of zero wind stress curl approximately parallel to the coast. Positive curl occurs inshore of the maximum wind stress. Negative curl in the offshore region is associated with the anticyclonic atmospheric circulation over the interior ocean. The positive curl near the coast is related to topography and to local features in the surface wind stress distributions.

The distributions from December to March are characterized by positive wind stress curl near the coast from San Francisco to northern Baja California, and south of Punta Eugenia. Large areas of associated Ekman divergence extend several hundred kilometers off the coast. The patterns of wind stress curl are less well behaved near the coasts of Oregon and Washington. However, negative wind stress curl near this coastal region appears to be typical of the distributions during the winter.

During spring and summer upwelling seasons, the dominant patterns of surface wind stress curl are easily recognized. The line of zero wind stress curl parallels the coast approximately 200 to 300 km offshore, along the entire boundary from northern Baja California to Vancouver Island, and from June through September. Yoshida and Mao (1957) placed this line at approximately 500 km from the coast. Considering the coarse resolution (5-degree squares of latitude and longitude) of their data, this disparity is not surprising.

The months of April-May and October-November appear as transitional periods. During transition from spring to summer, the negative curl along the coasts of Oregon and Washington shifts to positive curl. The offshore distribution takes on a more uniform character. Scattered regions of positive and negative curl are replaced by a large area of negative curl. The late fall transition is marked by a total breakdown in the curl distributions within the northern sector of the grid.

Several local (positive) curl maxima are associated with major topographic changes in the coastline configuration. Large values of positive wind stress curl are found near Cape Blanco, Cape Mendocino, San Francisco, and Point Conception. These features may be real, or they may be artifices of the finite difference calculations or the data distributions. However, one does note that near Point Conception, the values of positive wind stress curl are consistent with a decrease in the magnitude of the surface wind stress in the lee of the point. Where areas of positive wind stress curl extend offshore of capes, there would tend to be a continued, although much reduced, level of upwelling outside of the primary coastal upwelling regime.

A region of negative wind stress curl (Ekman convergence) reaches the coast of Baja California between Punta Eugenia and Punta Baja to the north. This feature appears consistently throughout the year. A partial breakdown in this system occurs in August, October, and November. However, considering the probable uncertainties in these derived data, one might reasonably conclude that the coastal region near Punta Eugenia can be characterized in the mean by convergence in the surface wind drift. The distributions of wind stress curl in this area imply favorable conditions for formation of fronts and convergent patches of recently upwelled water.

Coastal Time Series

The mean annual cycle of wind stress curl near the coast is shown in Figure 17. Positive wind stress curl occurs along most of the coast throughout the year. Exceptions to this generalization are found in the region south of lat. 30°N and between lat. 40°N and 47°N. The temporal persistence of the negative wind stress curl near Punta Eugenia (lat. 29°N) is clearly seen in this time series. A similar feature occurs near the tip of Baja California. Seasonal variation between positive and negative curl is apparent from Cape Mendocino to the Columbia River.

Yoshida and Mao (1957) presented evidence indicating that open-ocean upwelling is related to wind stress curl. This process is distinct from coastal upwelling which is primarily a boundary phenomenon. However, the two mechanisms are not totally independent. In regions where positive wind stress curl occurs, such as between lat. 30°N and 40°N throughout the year, and near the coasts of Oregon and Washington during the summer, ascending motion related to the wind-induced divergence offshore enhances the upwelling associated with the more dominant coastal divergence.

DISCUSSION

Monthly distributions of surface wind stress show an offshore maximum which progressively develops over a large extent of the California Current and shifts northward and intensifies from winter to summer. This process is a primary forcing function for coastal upwelling. Off Baja California, wind-induced surface divergence occurs on average throughout the year. Downwelling occurs near the coast of Vancouver Island, except during the restricted period between May and August when a small equatorward component of surface wind stress is observed.

The major seasonal variations in the magnitude and direction of the surface wind stress can be described

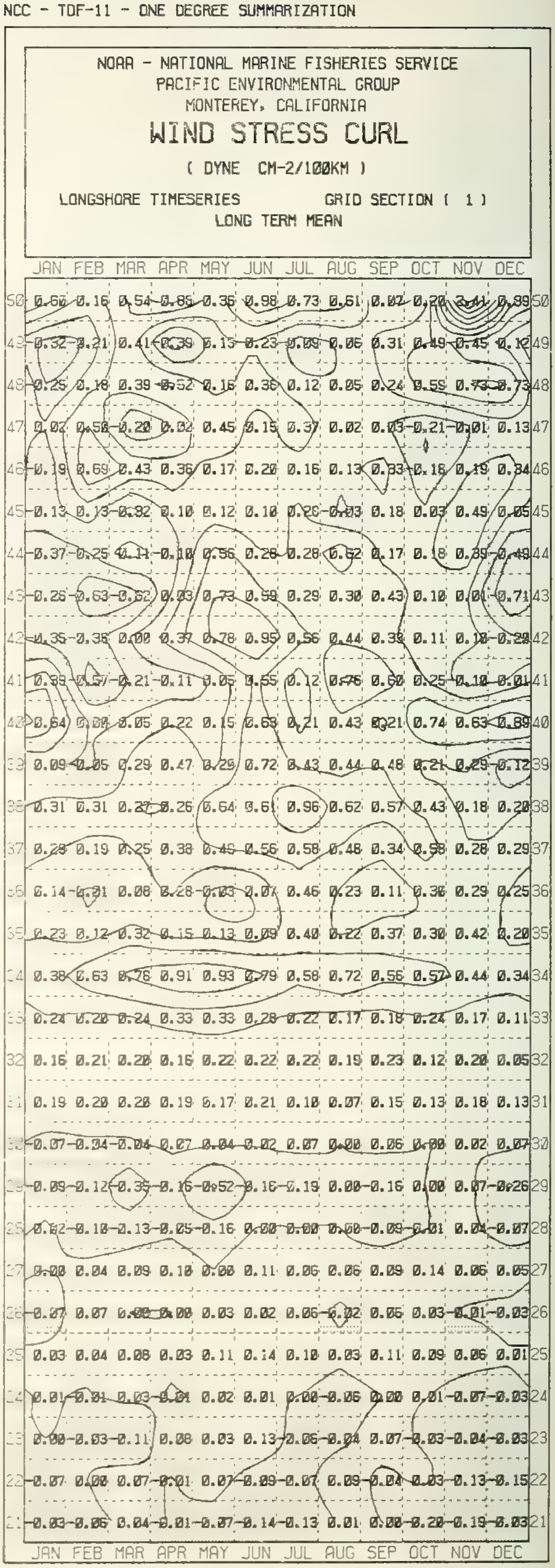


Figure 17.—Seasonal cycle of wind stress curl near the coast. The wind stress curl is shown by month for the 1-degree squares immediately adjacent to the coast. The calculations were based on the monthly mean surface wind stress distributions. Units are dyne cm^{-2} per 100 km. The contour interval is 0.25 dyne cm^{-2} per 100 km. Negative values are shaded. Numbers along ordinate are degrees north latitude.

simply in terms of the general atmospheric circulation over the northeast Pacific Ocean. Monthly mean surface pressure charts typically show two well-developed pressure cells. A high pressure system over the ocean shifts northward and increases in strength from winter to summer. The center of the cell moves in a northwestward direction. This shift in the large-scale anticyclonic circulation results in the observed winter to summer reversal in the alongshore component of wind off the coasts of Oregon and Washington. A low pressure system is situated over the southwestern United States. This semipermanent thermal low is fully developed over the Central Valley in California during the summer. Cyclonic circulation associated with the low leads to equatorward surface wind stress parallel to the coast. The amplitude of the annual cycle is large. During winter, both of these pressure cells weaken. The high pressure system moves southward and the coasts of Oregon and Washington come under the influence of the intense low pressure system in the Gulf of Alaska.

The primary mechanism controlling the location and strength of the wind stress maximum and the associated coastal upwelling is described by seasonal variations in the gradient between the two pressure cells. During the winter, this gradient is weak. Strong heating over the continent during summer deepens the low and increases the amplitude of the onshore-offshore pressure gradient. As a result of the northward shift and strengthening of the high, and deepening of the low, the region of maximum wind stress moves from the area south of Point Conception to the vicinity of Cape Mendocino. These variations are, of course, a function of differential ocean-continent heating related to the annual cycle of solar radiation.

Physical Implications

Climate of the adjacent coastal regions is influenced by upwelling. During summer, the dome of high pressure which develops over the North Pacific Ocean favors large-scale subsidence and a strong temperature inversion over the west coast of the United States. This suppresses deep cloud formation and greatly inhibits precipitation. Unpublished distributions of cloud cover,[6] summarized from ship observations, show a large onshore-offshore gradient in the total cloud amount. Minima occur at the coast. The effect of the large-scale subsidence is noted in the true desert climate of Baja California, and in the almost complete lack of rainfall along the coasts of California, Oregon, and Washington during the summer. Coastal upwelling primarily influences the local climate of the nearshore zone within 10 to 20 km of the coast and contributes to the formation of low stratus clouds and fog typical of much of the coast along California and Oregon.

A secondary mechanism may account for local intensification of surface wind stress and persistence of coastal upwelling over periods ranging from several weeks to a few months (Bakun 1974). In a simplified positive feedback model, wind stress parallel to the coast brings cold water to the surface and cools the adjacent air. The resulting temperature contrast between the continent and the ocean increases the local pressure gradient. Alongshore surface winds are increased and upwelling is enhanced (Ramage 1971). This mechanism may be slightly modified by the effect of atmospheric stability. In the summertime coastal upwelling zone, the air-sea temperature difference is usually positive. This stable stratification decreases the magnitude of the surface wind stress. The resulting negative feedback may partially offset the increase in surface winds associated with the described changes in the local pressure gradient.

The existence of maximum wind stress some 200 to 300 km from the coast is an interesting feature. Of course, a maximum in the onshore-offshore pressure gradient offshore may explain this phenomenon. Positive feedback associated with wind-induced upwelling extending hundreds of kilometers off the coast may act to intensify the alongshore winds. However, this feature also suggests a coastal boundary layer which acts to frictionally retard the winds near the coast, leading to a positive wind stress curl in the nearshore region.

A characteristic feature of the wind stress curl distributions is the occurrence of a line of zero curl at some distance from the coast. Observations show positive curl inshore of this line and negative curl in the offshore region. A theoretical analysis suggests that a poleward undercurrent along an eastern boundary is favored by positive wind stress curl along the coast and a poleward decrease in surface heating (Pedlosky 1974a). The monthly distributions of wind stress curl presented in this study are generally consistent with an equatorward Sverdrup flow offshore and a poleward Sverdrup flow near the coast, except in the region from Punta Eugenia to Punta Baja, where the wind stress curl is negative. The general pattern of positive wind stress curl along the coast and observations of the California Countercurrent (Wooster and Jones 1970; Wickham 1975) are consistent with Pedlosky's theory.

The Sverdrup transport balance expressed in Equation (6) may provide a simple and reasonable explanation for the existence of the current-countercurrent system observed along the west coast of the United States. Transport calculations, based on the July wind stress curl data for the line of 1-degree squares extending offshore of Cape Blanco (lat. 43°N), show a net southward transport of 3.5×10^{12} g s^{-1}. Within 300 km of the coast, an integrated northward transport of 2.2×10^{12} g s^{-1} is required. Negative wind stress curl between long. 127°W and 133°W is associated with a southward vertically integrated mass transport of 5.7×10^{12} g s^{-1}. These values underestimate, by a factor of two, the total volume transport of 10 sv (1 sverdrup = 10^6 m^3 s^{-1}) for the California Current suggested by Sverdrup et al. (1942:724).

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[6] Distributions of monthly mean cloud cover over the California Current are on file at Pacific Environmental Group, National Marine Fisheries Service, NOAA, Monterey, CA 93940.

A relationship between wind stress curl and the California Current system has been suggested. The data indicate that the poleward undercurrent observed along the west coast of North America may be driven locally by positive wind stress curl. However, a possibility does exist that the boundary current is not entirely the result of local forcing. Coastal areas may respond to wavelike disturbances propagating from other regions of the ocean (Wyrtki 1975), or to other nonlocal processes (Pedlosky 1974b).

Biological Implications

Relationships among patterns of coastal and equatorial upwelling and distributions of primary production have been discussed by Cushing (1969). Favorable conditions for phytoplankton growth are maintained within surface photic layers by upwelling of nutrient-rich subsurface water. Offshore divergence related to the curl of the wind stress effectively extends the width of the biological upwelling zone. Fronts may form in areas of negative wind stress curl just offshore of the primary coastal convergence, such as near Punta Eugenia. These fronts would tend to concentrate both the available food and the grazers within the same areas. This process may be important to survival of fish stocks which spawn in this coastal region.

Seasonal changes in surface circulation may also provide mechanisms for survival and possible separation of stocks along the coast. The current-countercurrent system characteristic of southern California suggests a mechanism whereby pelagic fish could migrate seasonally from primary feeding grounds within the coastal upwelling regime off northern California to spawning grounds off Baja California.

A general requirement for vertically integrated northward Sverdrup transport along the coast apparently breaks down near Punta Eugenia where negative wind stress curl is observed (Fig. 18A). In this region, there must be southward vertically integrated Sverdrup transport.

With this consideration in mind, it is interesting to note the winter distribution of surface currents depicted in Figure 18B. The large-scale pattern suggests two separate cyclonic gyres associated with positive wind stress curl in the Southern California Bight, and south of Punta Eugenia. In the region of negative wind stress curl, the indicated surface flow is toward the south.

The importance of coastal upwelling, offshore divergence, and patterns of surface circulation to the early survival of larvae in the California Current region has been recognized (Anonymous 1952). The correspondences of features in the patterns of wind stress curl, surface currents, and winter distributions of the northern anchovy, *Engraulis mordax*, (Vrooman and Smith, 1971), shown in Figure 18C, are highly suggestive of larval transport mechanisms which could lead to formation of subpopulations of pelagic fishes in the California Current. These mechanisms have been described by

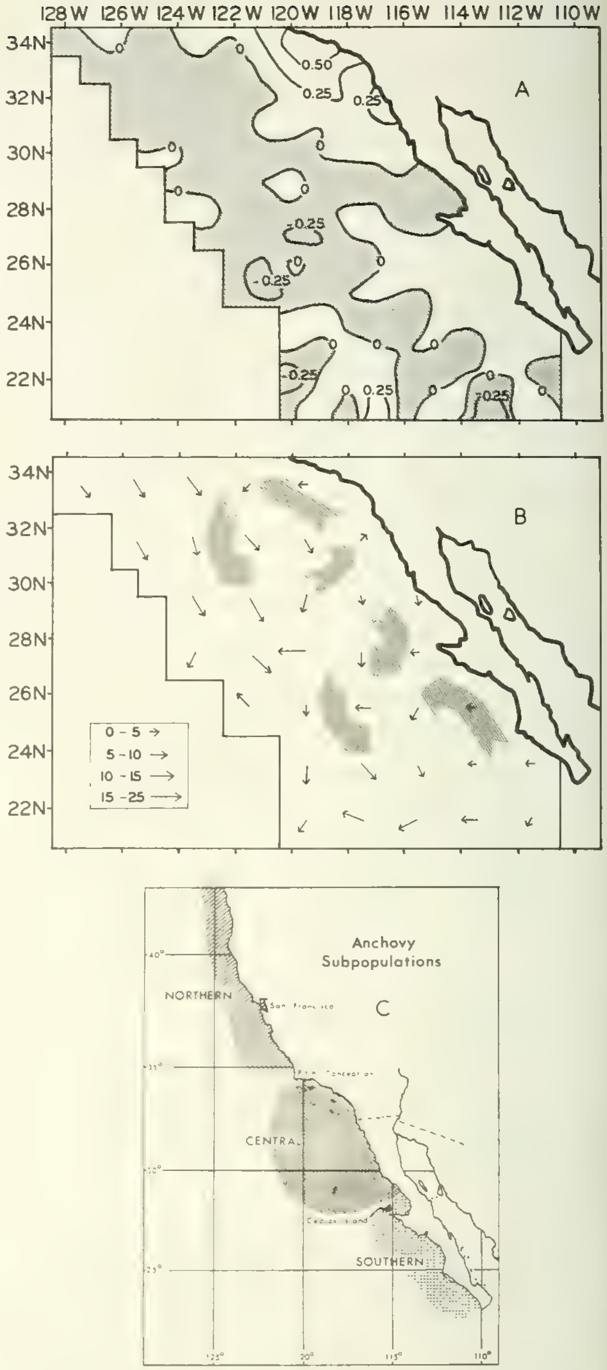

Figure 18.—Distributions of: A. wind stress curl, B. surface currents, and C. anchovy subpopulations. Wind stress curl is shown for September. Units are dyne cm $^{-2}$ per 100 km. The contour interval is 0.25 dyne cm^{-2} per 100 km. Negative values are shaded. The winter distribution of surface currents is depicted in terms of 2-degree summarizations of ship drift data. Vector symbols are scaled according to the key on the chart. Units are cm s^{-1}. Large arrows suggest the split cyclonic circulation which develops off southern California and Baja California. The winter distributions of the three subpopulations of northern anchovy are shown in the bottom figure. Figure C is after Vrooman and Smith (1971).

Parrish (1976). Distributions of Pacific mackerel, *Scomber japonicus*, are similar to those for central and southern subpopulations of northern anchovy shown in Figure 18C.

CONCLUSIONS

The present study has demonstrated the utility of historical marine observations in describing details of surface properties over an area of the North Pacific Ocean. Resolution by 1-degree square and long-term month is feasible when the amplitude of the seasonal cycle is large. This method of summarization may fail in regions of sparse data, or in the tropics where long-term fluctuations frequently obscure the seasonal cycle.

Summarization of these data by 1-degree square, month, and year often fails to produce consistent time series. The resulting fields may not be statistically significant if the mean values are based on too few observations. Objective analysis provides a method to obtain consistency in time and space. However, with these methods, continuity in time is gained at the expense of spatial resolution. An empirical approach might be used to calibrate the large-scale analyzed fields in terms of the features evident in higher resolution distributions, such as those presented in this report. The resulting time series could be related to fluctuations of marine biological communities which must respond to wide variations in environmental conditions on time scales ranging from a few days to several years.

ACKNOWLEDGMENTS

The author is indebted to Andrew Bakun for his original suggestions, constructive criticism, and continued encouragement throughout the course of this work. Gunter R. Seckel and David M. Husby provided invaluable advice, many stimulating discussions, and reviewed the completed manuscript. Grateful appreciation is extended to James H. Johnson for providing the opportunity to complete this research. All are colleagues at the Pacific Environmental Group, National Marine Fisheries Service, NOAA. Historical surface marine data and electronic computing and plotting facilities were provided by the U.S. Navy, Fleet Numerical Weather Central.

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APPENDIX I

Monthly Surface Wind Stress Distributions

The long term composite monthly mean surface wind stress distributions are displayed in Charts 1 to 12 as resultant vectors, in Charts 13 to 24 as the eastward components, and in Charts 25 to 36 as the northward components. The values are plotted in units of dyne cm^{-2}. The month is indicated in the figure legend in the upper right corner of the charts. The two years displayed below the month, for example 1858-1972, correspond to the year of the earliest report and the year of the most recent report, respectively. The coastline configuration is superimposed on the grid as a visual aid and does not represent a conformal mapping.

In Charts 1 to 12, the vectors are plotted according to the scale shown below the figure legend. The mean vector magnitudes are contoured at intervals of 0.5 dyne cm^{-2}. Magnitudes greater than 1.0 dyne cm^{-2} are shaded.

Charts 13 to 24 display contoured values of the eastward component of the resultant surface wind stress. The contour interval is 0.5 dyne cm^{-2}. Positive values correspond to eastward components. Negative values are shaded.

The northward component of the resultant stress is plotted in Charts 25 to 36. The contour interval is 0.5 dyne cm^{-2}. Positive values correspond to northward components. Negative values are shaded.

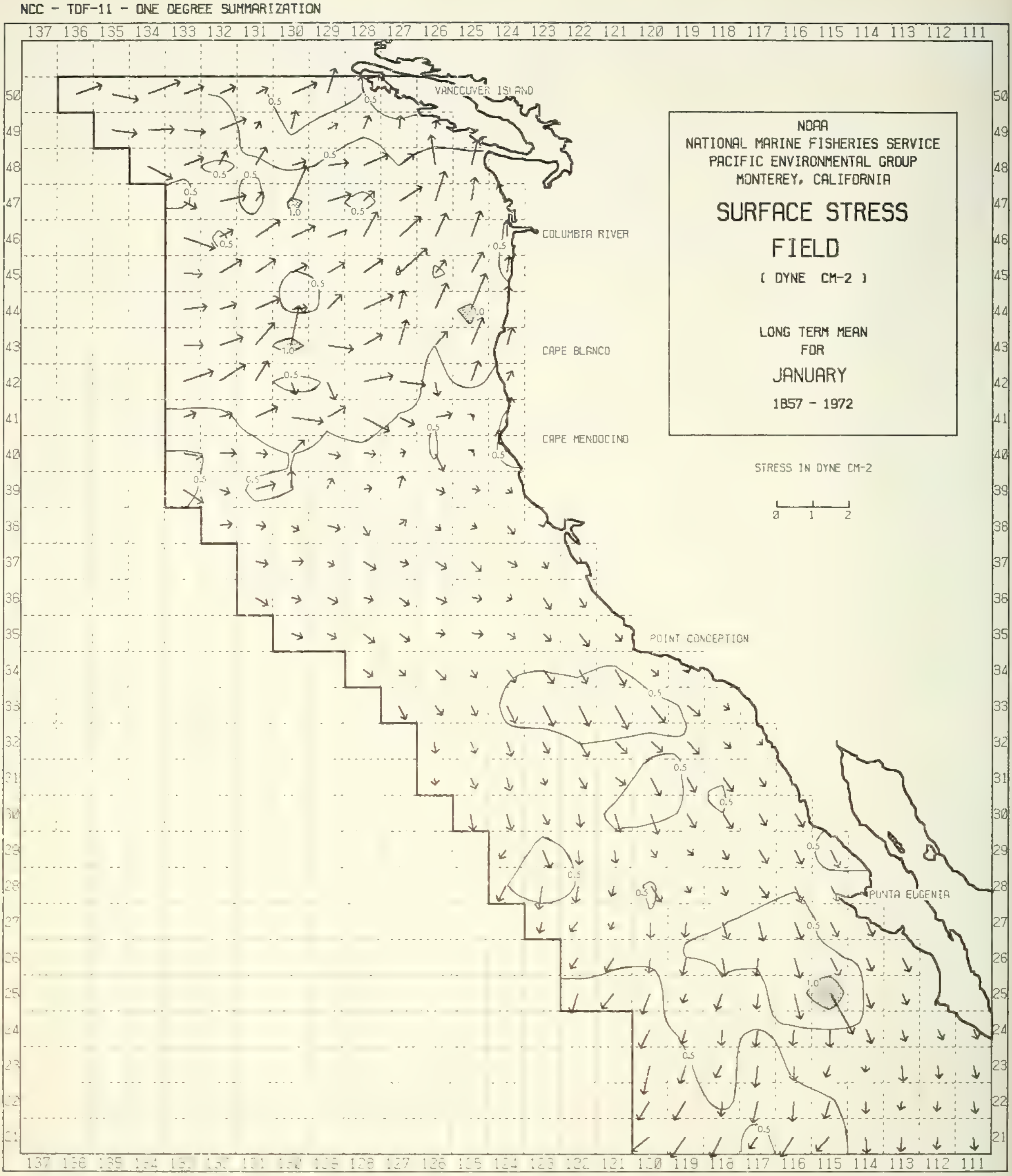


Chart 1.—Resultant surface wind stress vectors for January.

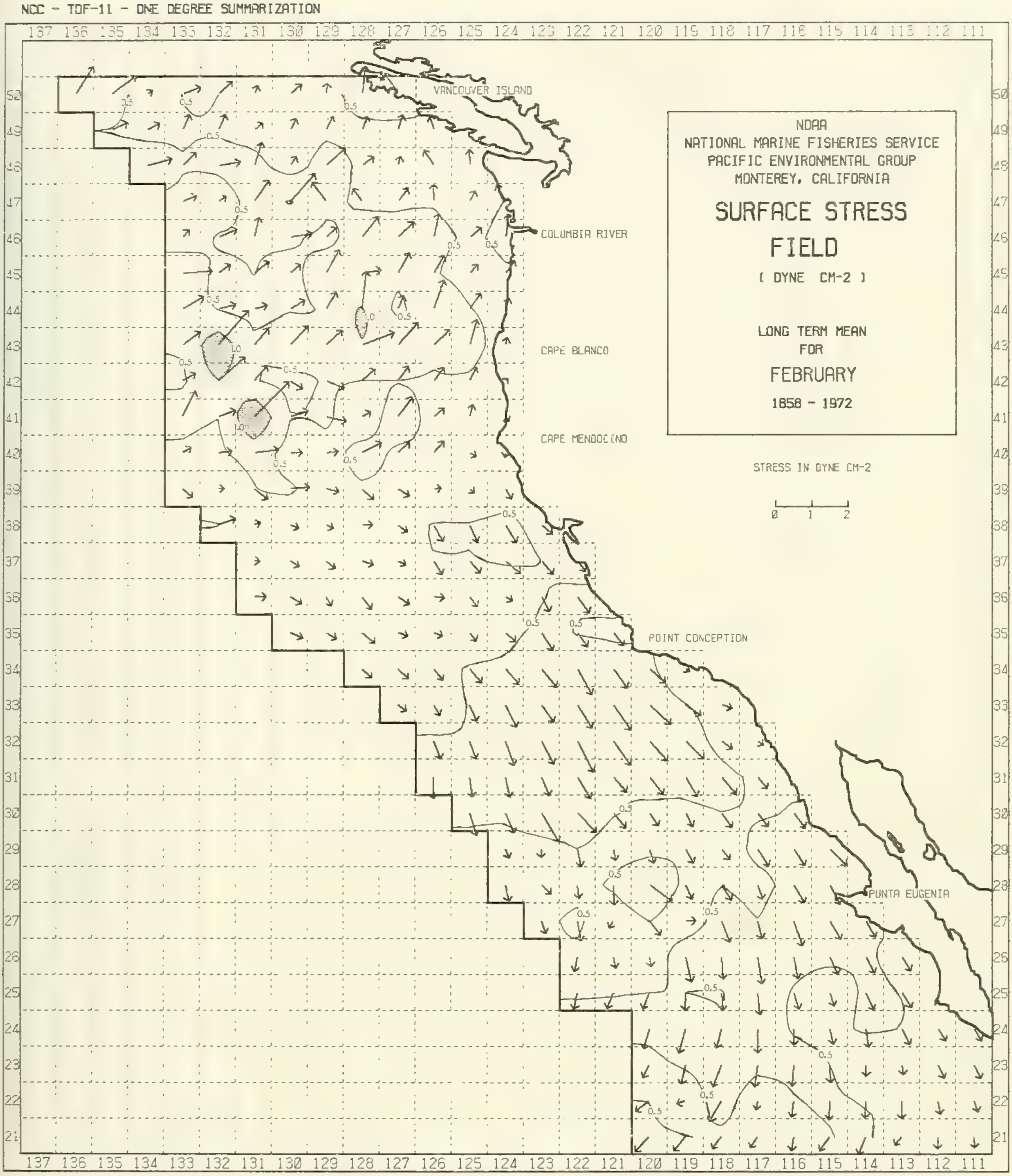


Chart 2.—Resultant surface wind stress vectors for February.

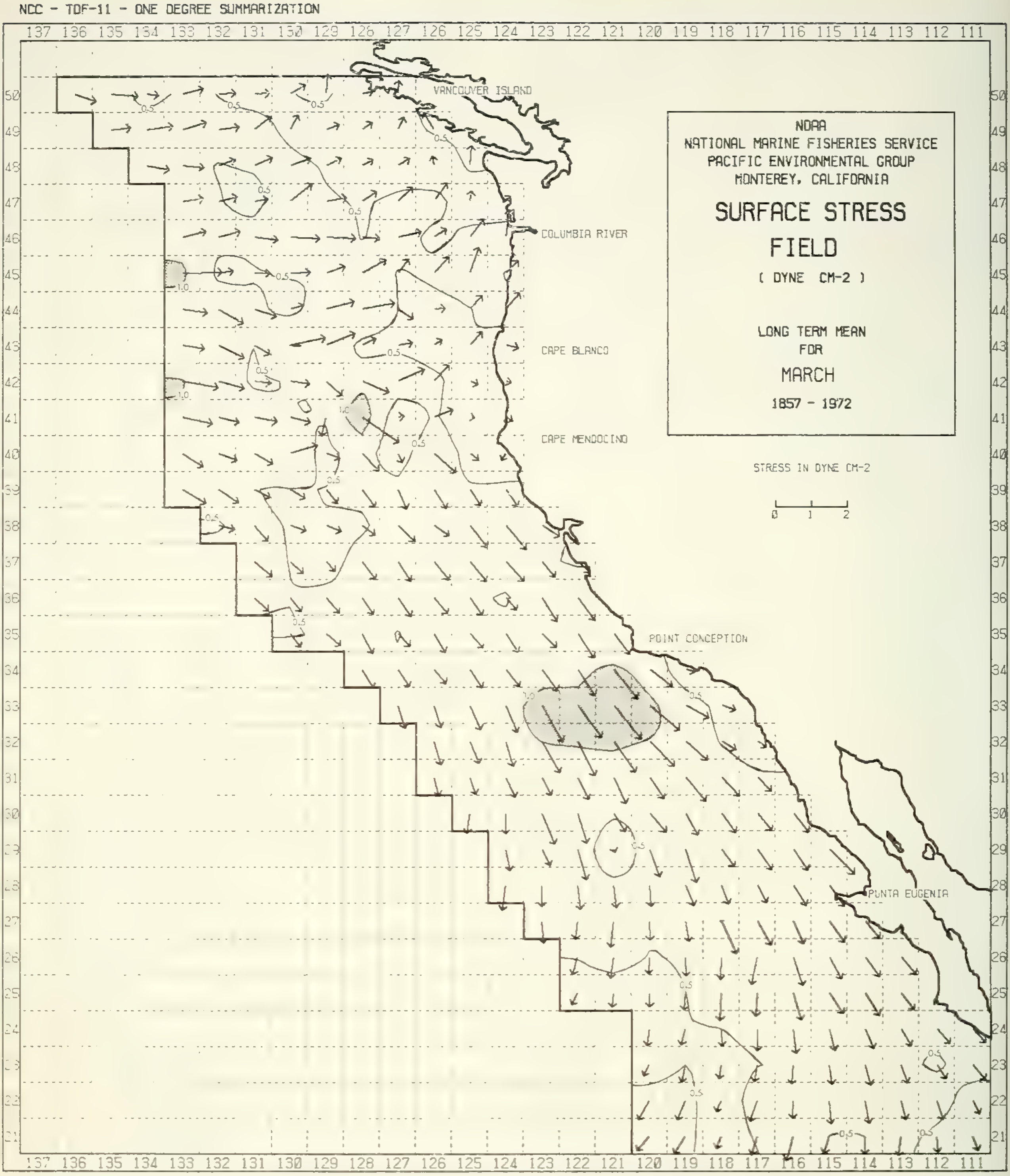


Chart 3.—Resultant surface wind stress vectors for March.

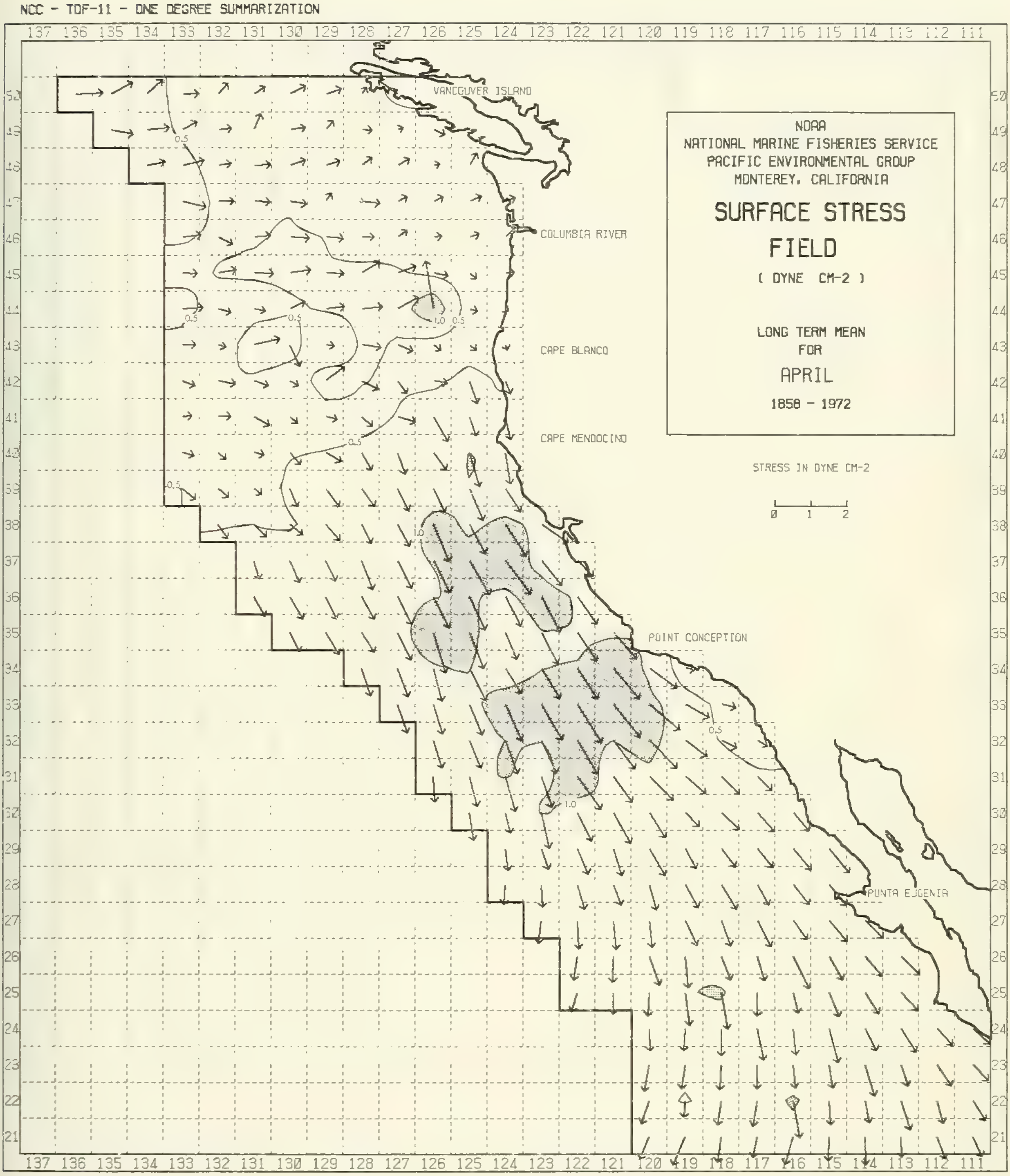


Chart 4.—Resultant surface wind stress vectors for April.

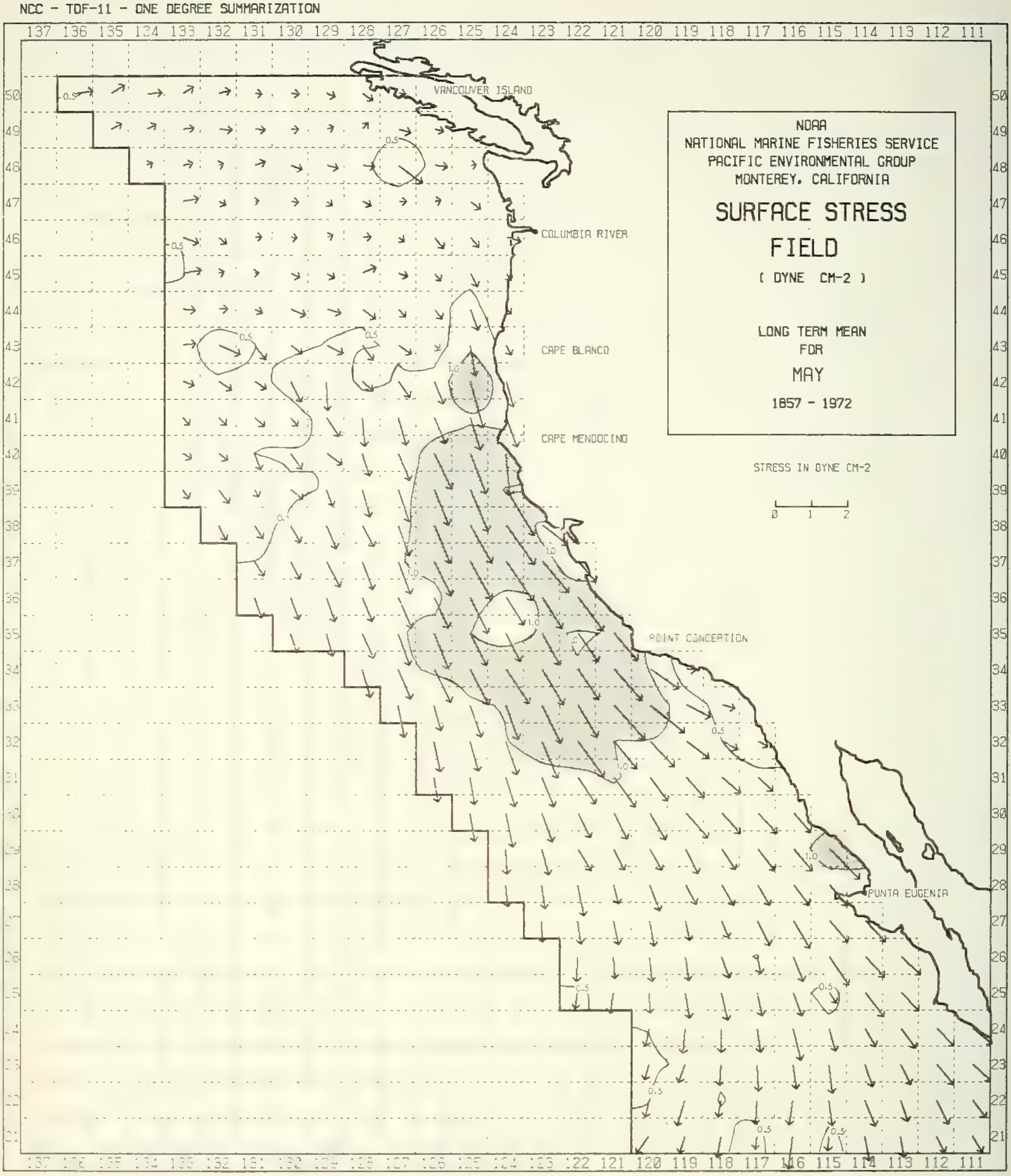


Chart 5.—Resultant surface wind stress vectors for May.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION

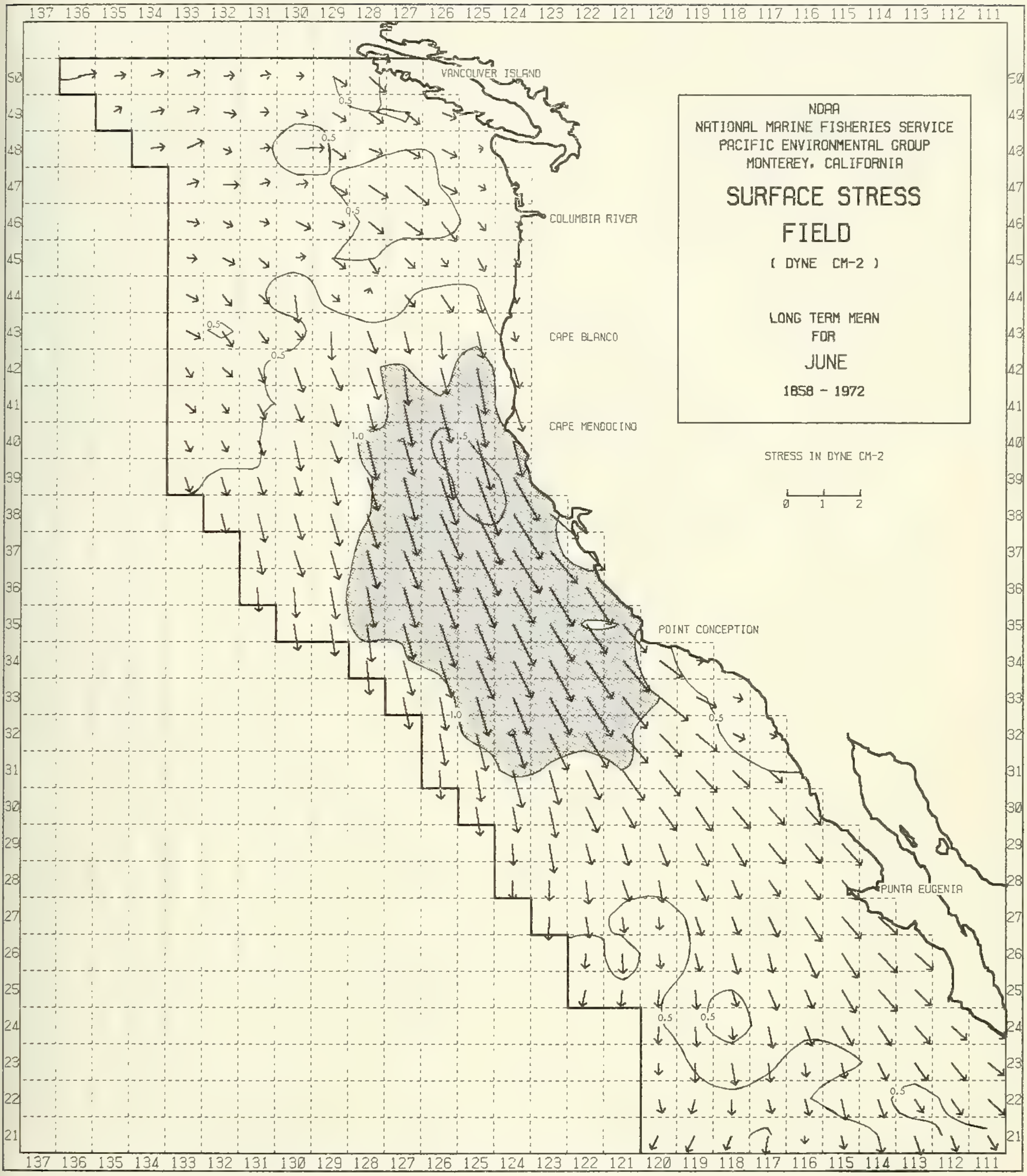


Chart 6.—Resultant surface wind stress vectors for June.

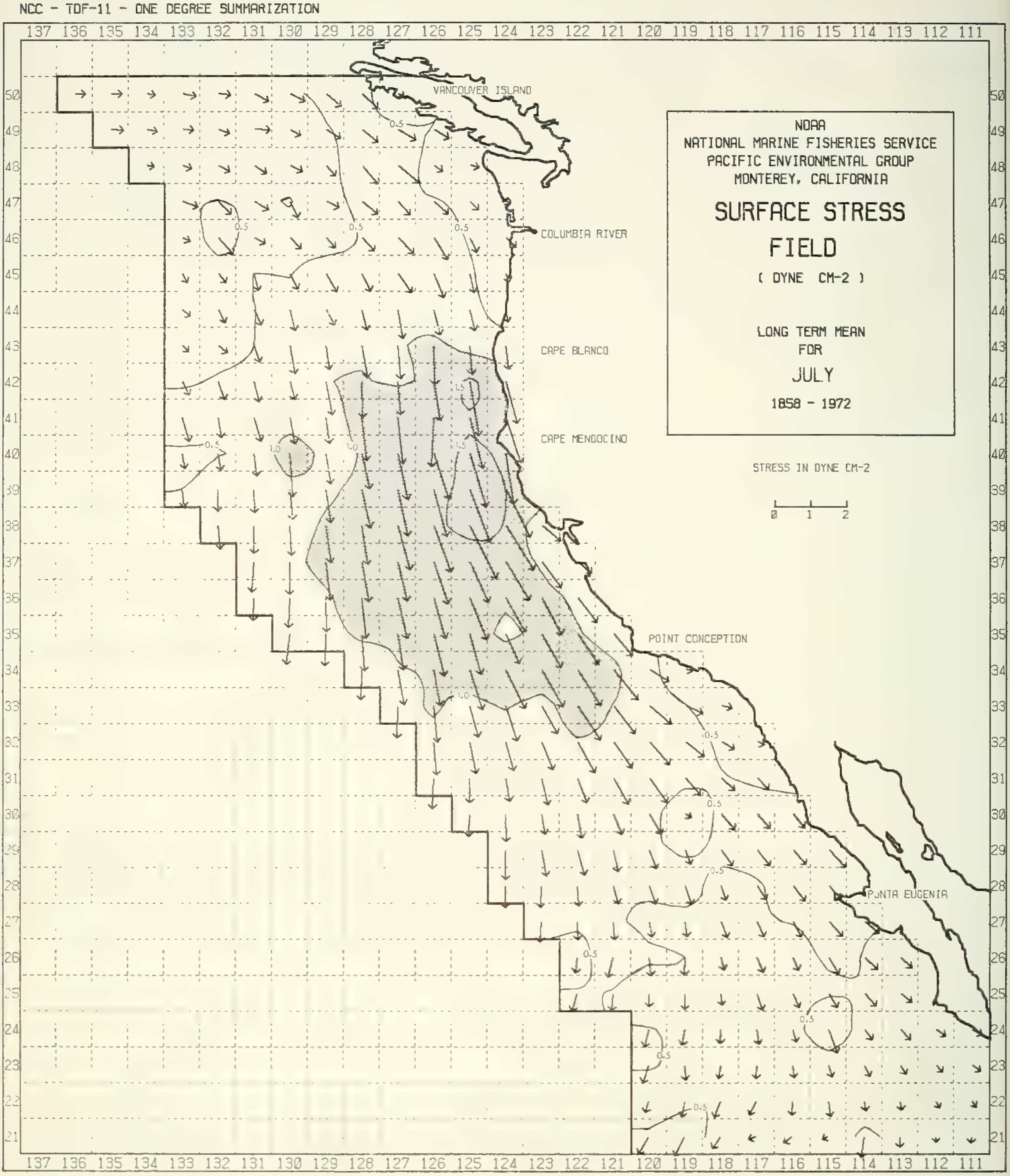


Chart 7.—Resultant surface wind stress vectors for July.

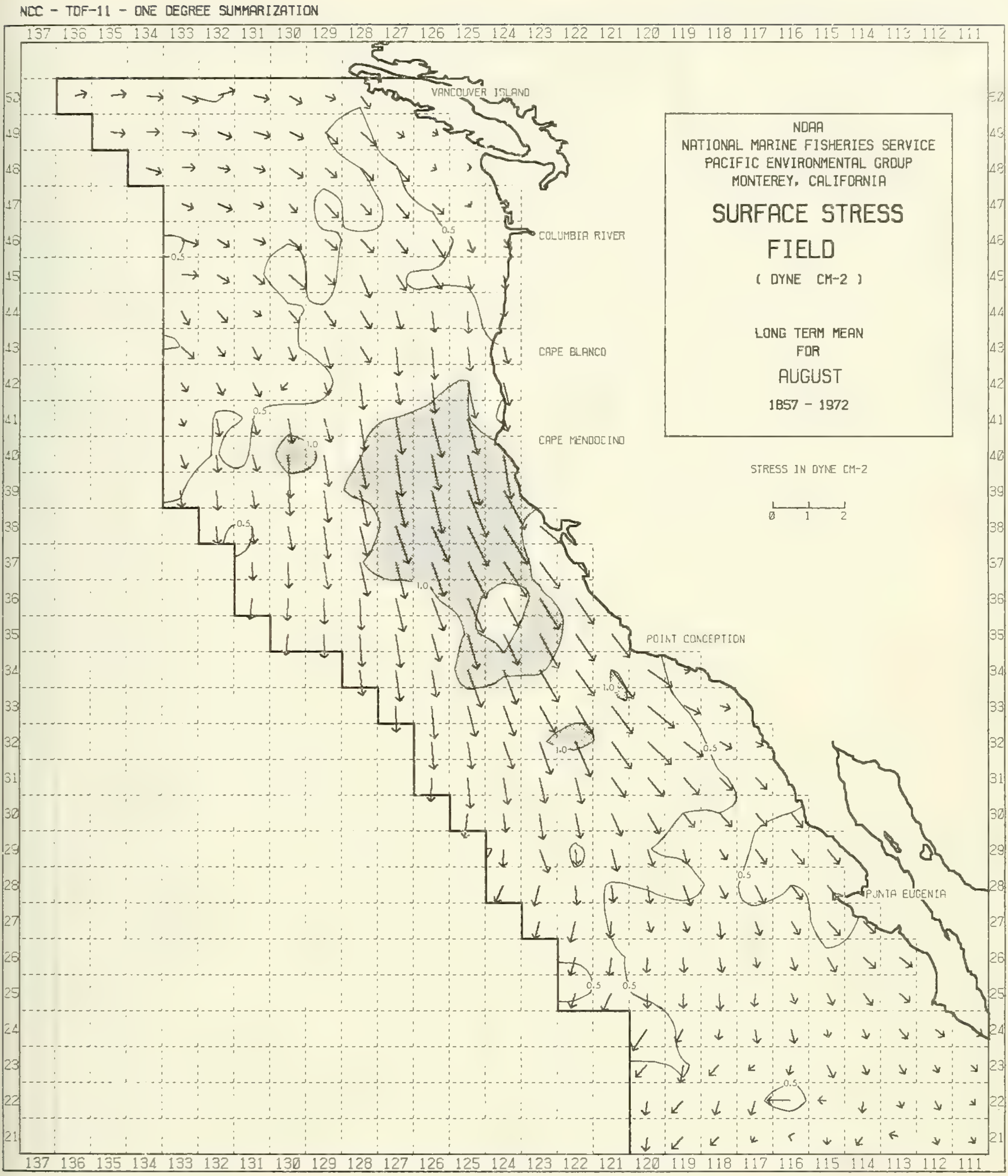


Chart 8.—Resultant surface wind stress vectors for August.

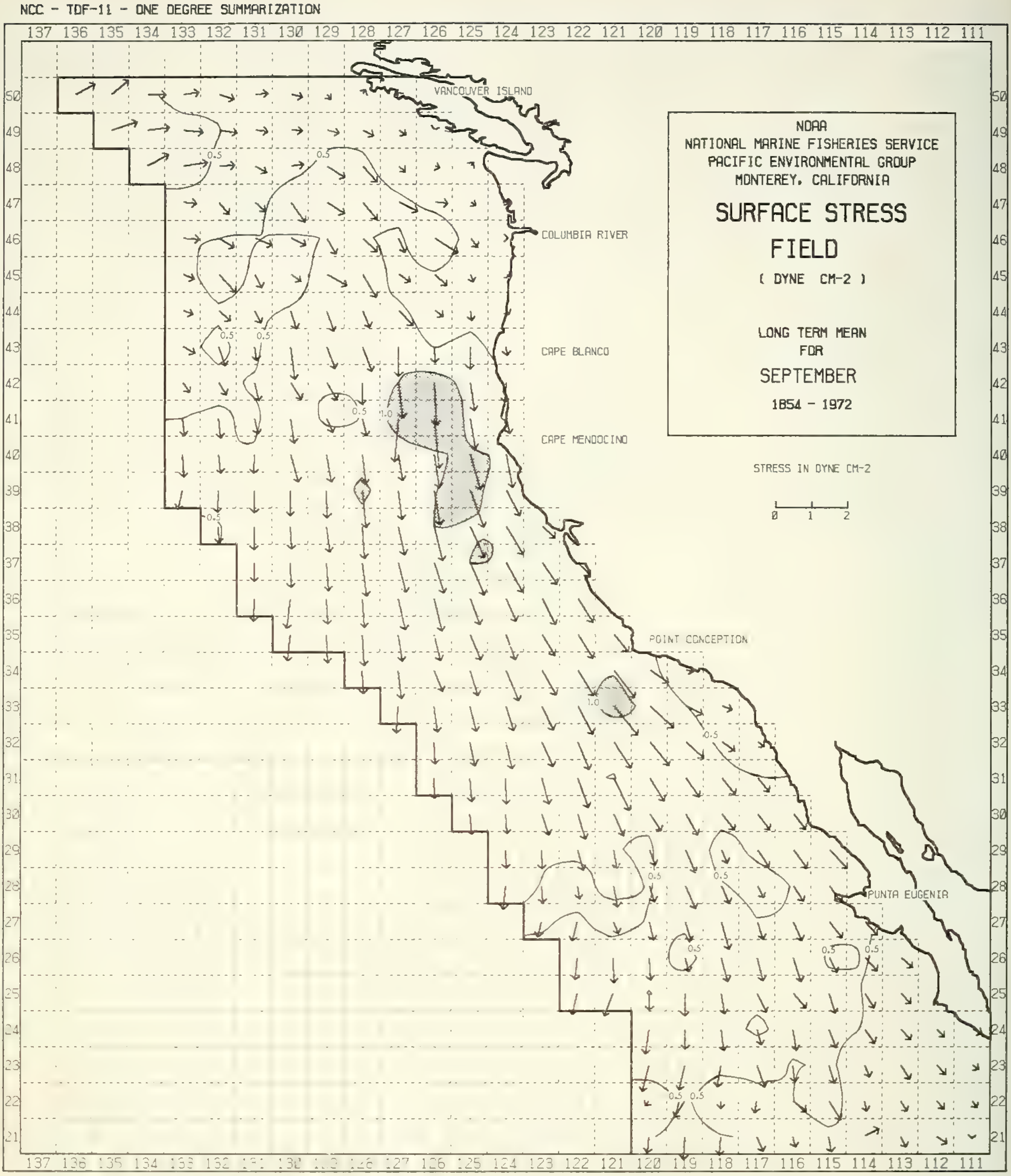


Chart 9.—Resultant surface wind stress vectors for September.

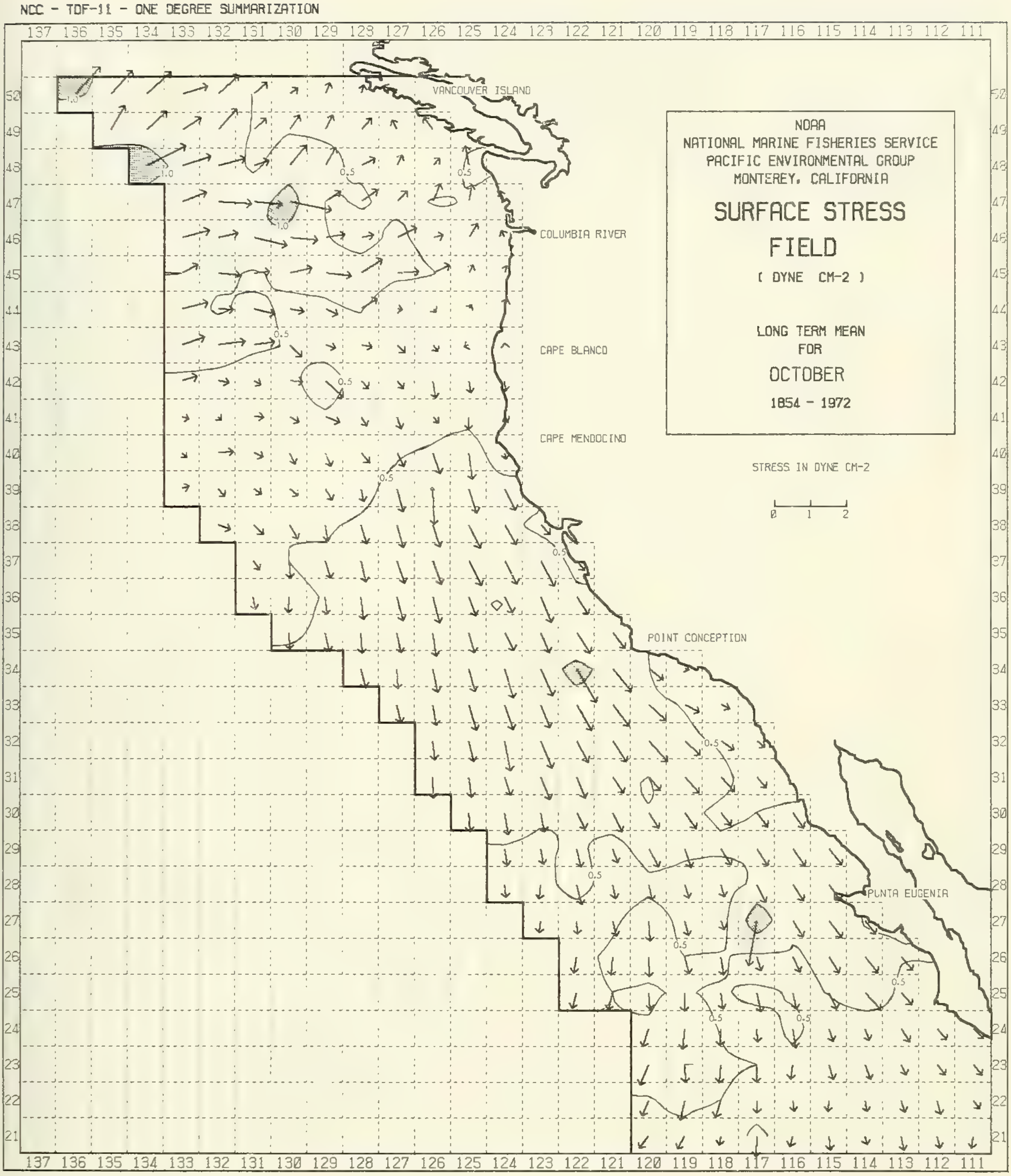


Chart 10.—Resultant surface wind stress vectors for October.

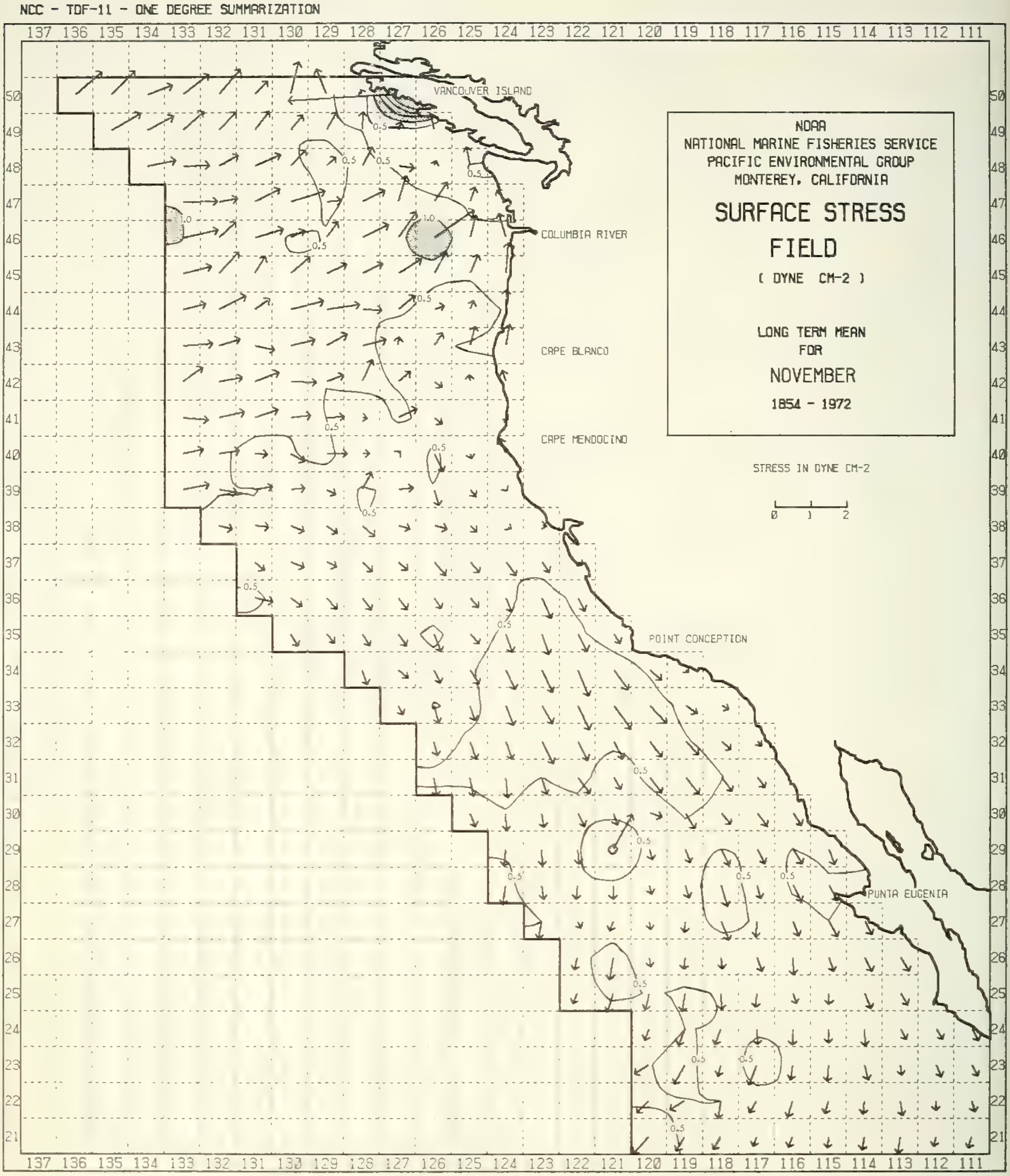


Chart 11.—Resultant surface wind stress vectors for November.

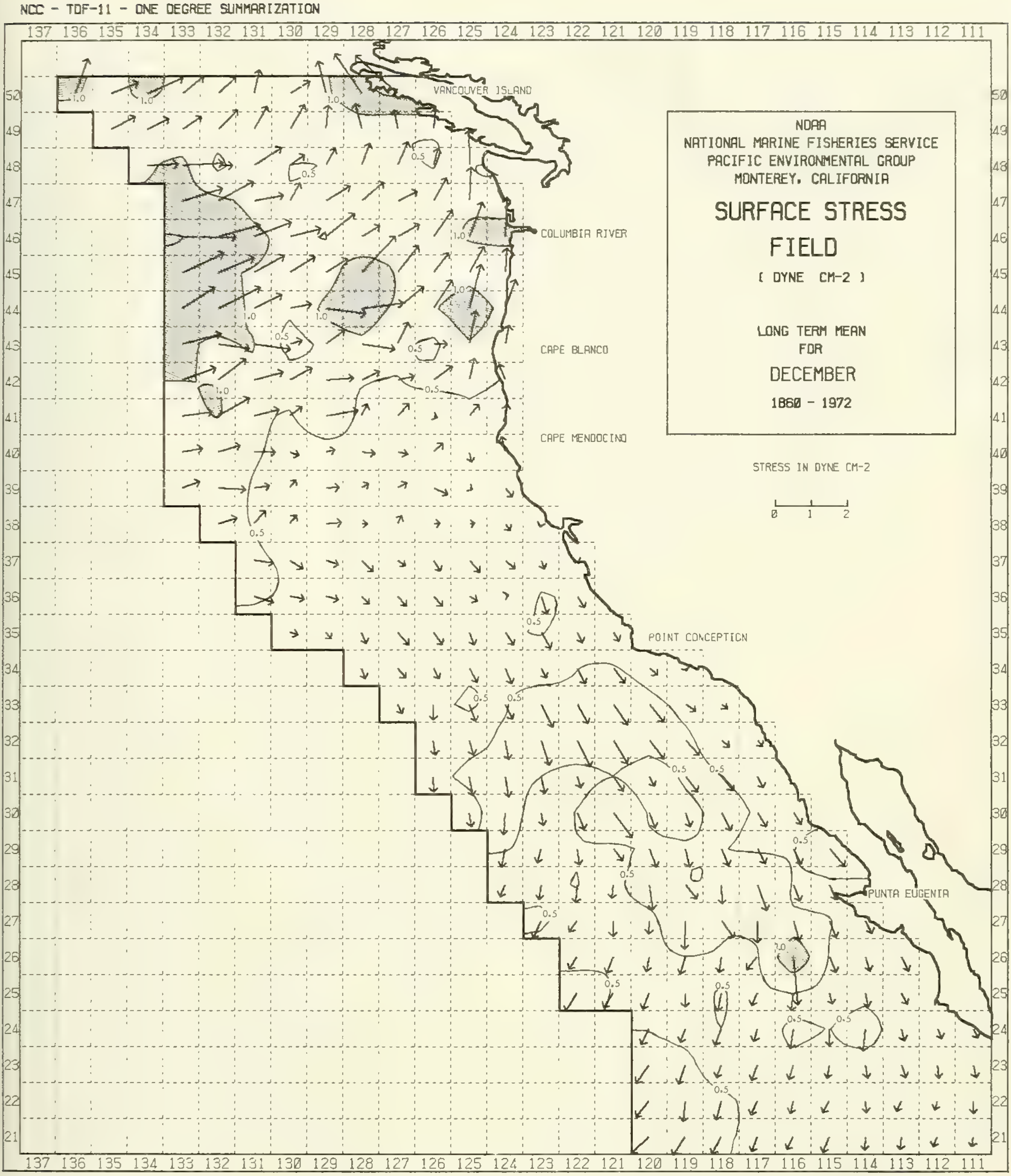


Chart 12.—Resultant surface wind stress vectors for December.

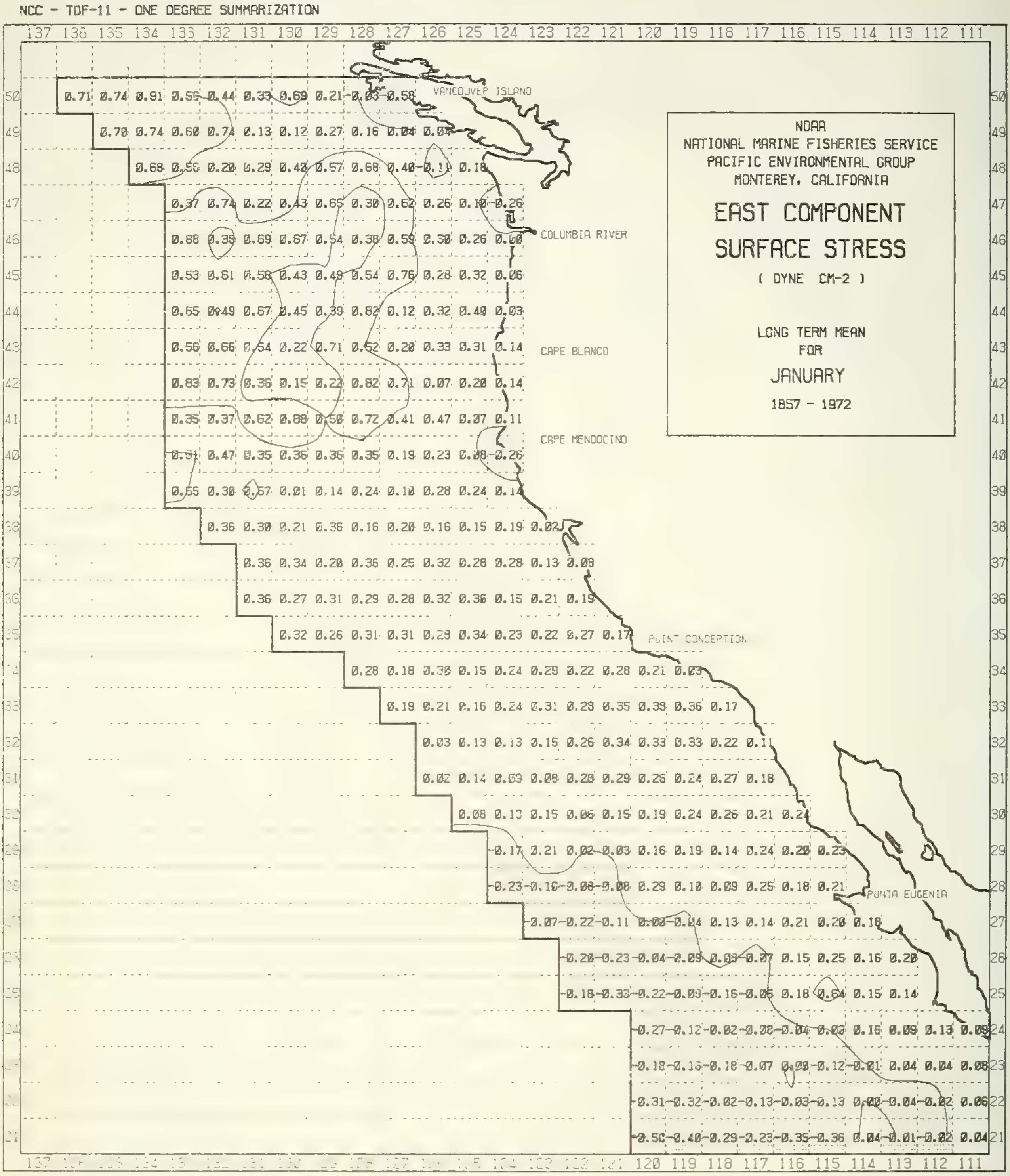


Chart 13.—East component surface wind stress for January.

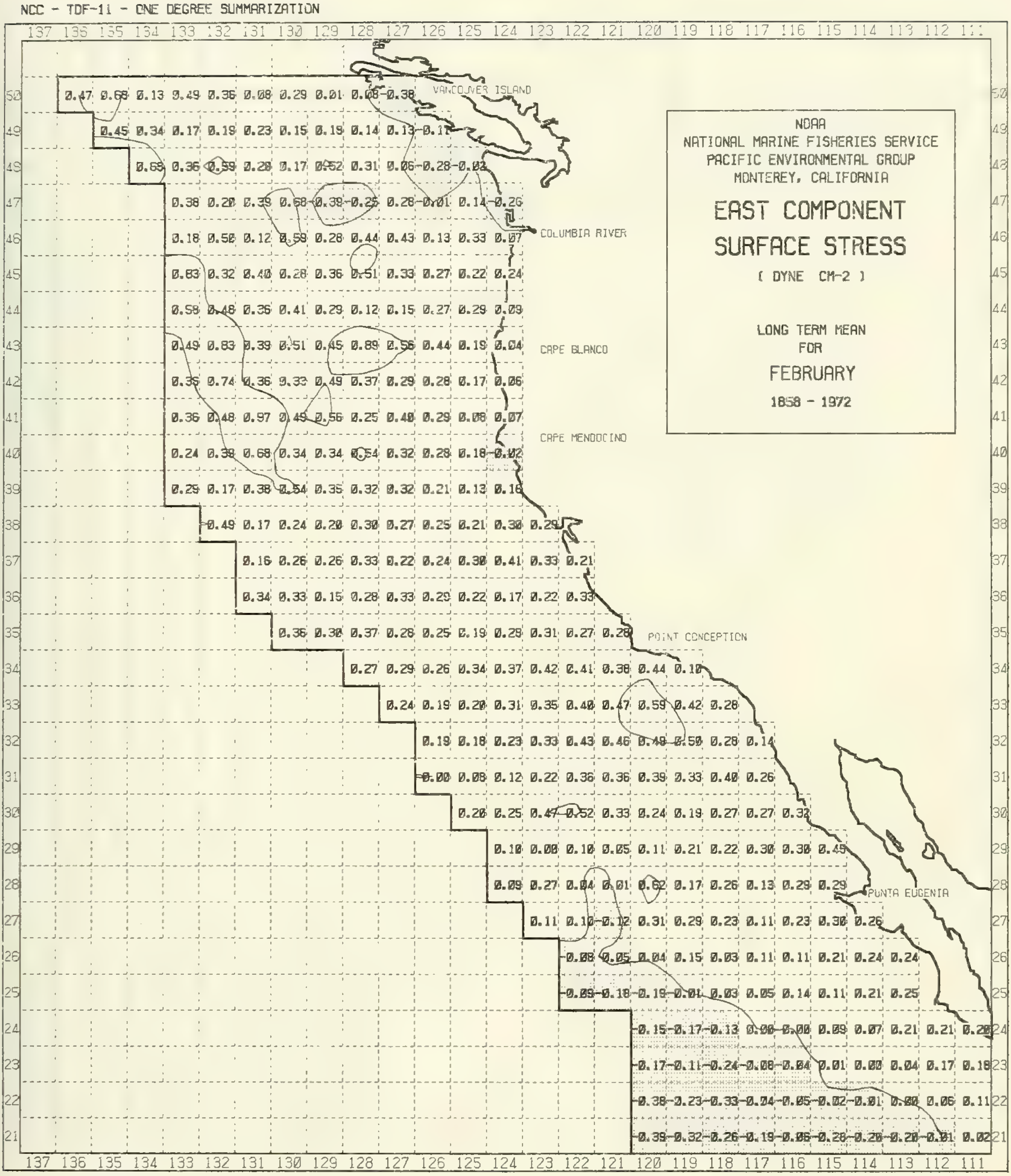


Chart 14.—East component surface wind stress for February.

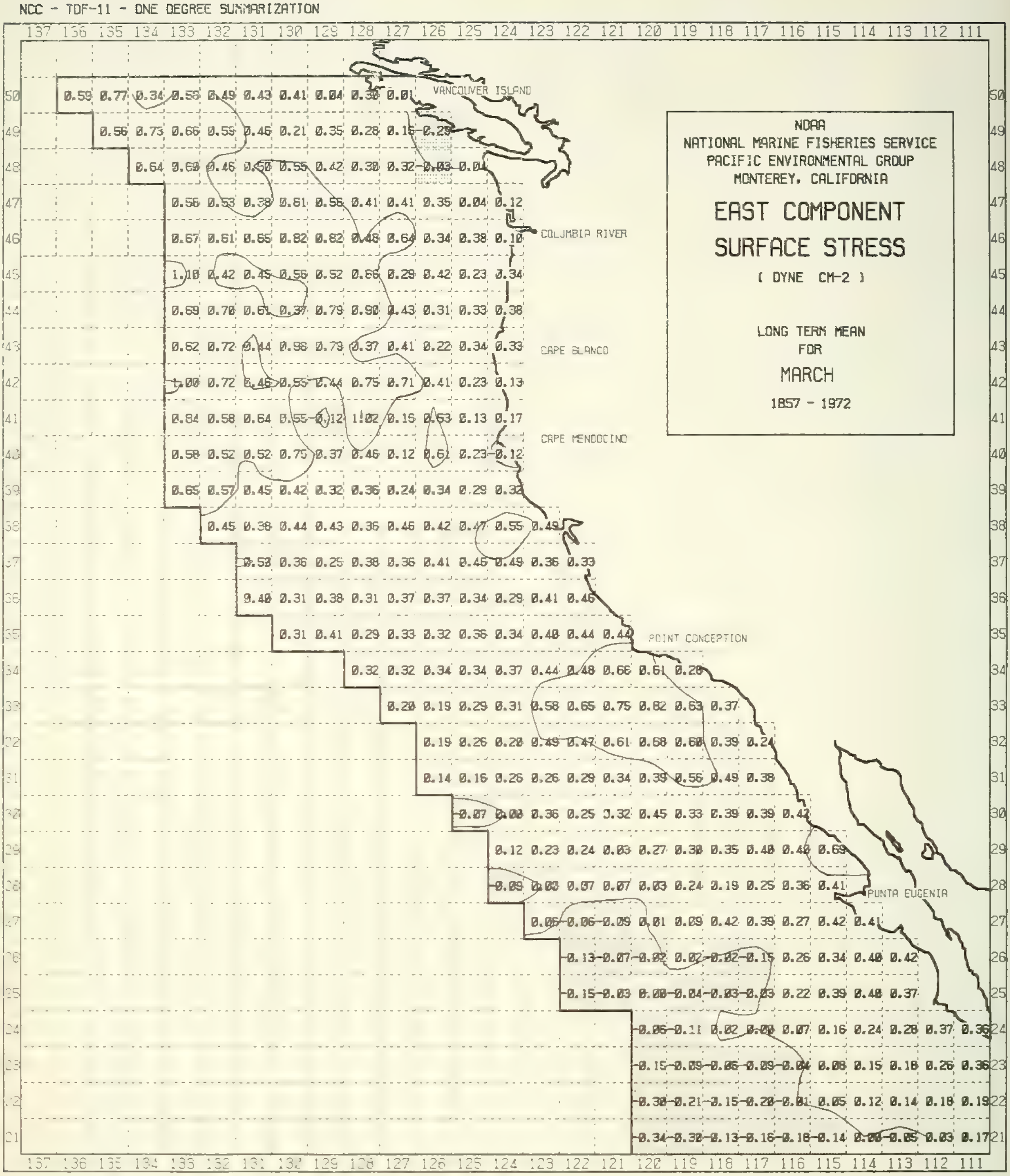
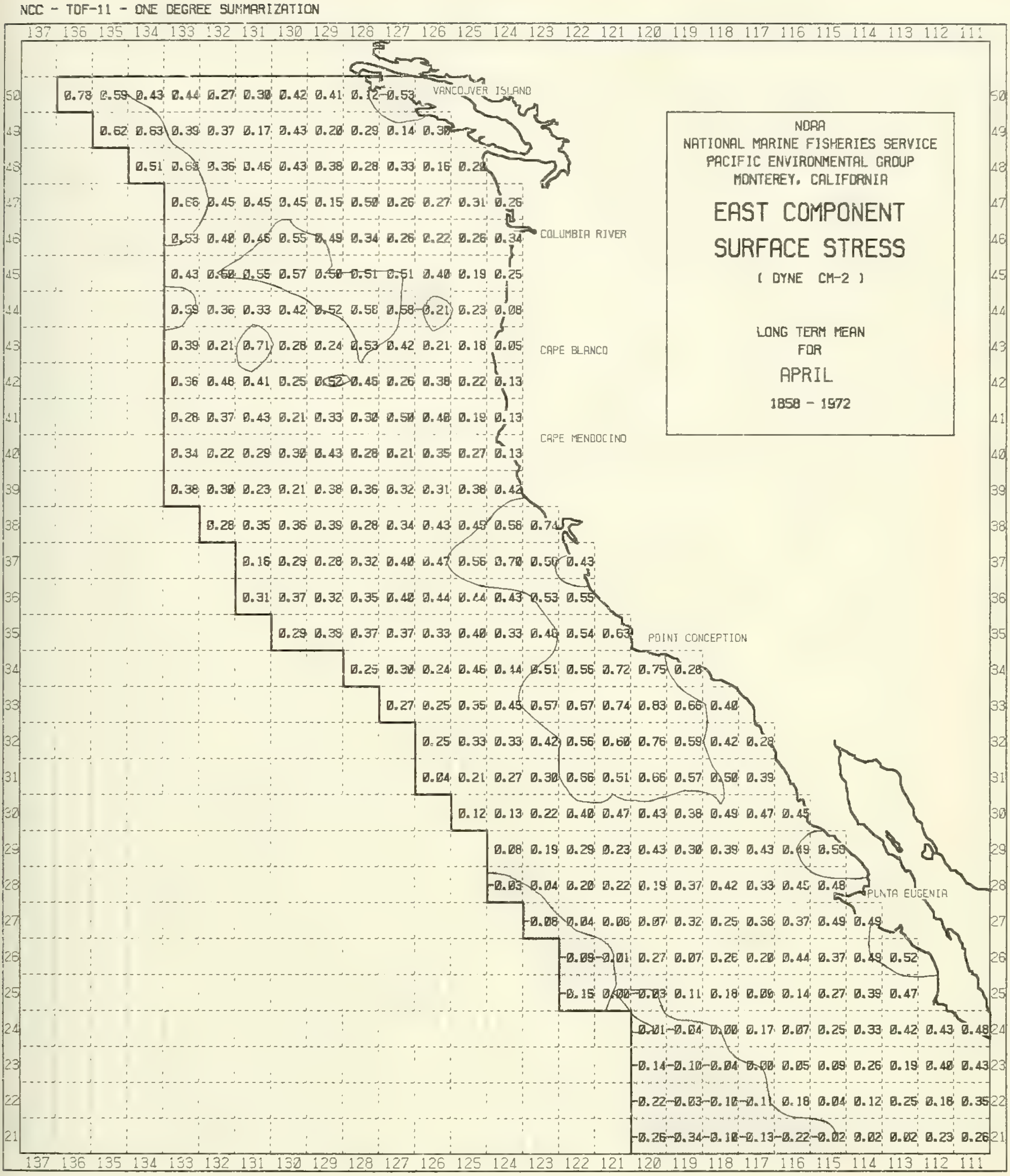


Chart 15.—East component surface wind stress for March.



	136	135	134	133	132	131	130	129	128	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112	111
50	0.78	0.59	0.43	0.44	0.27	0.30	0.42	0.41	0.12	0.53																
49		0.62	0.63	0.39	0.37	0.17	0.43	0.20	0.29	0.14	0.30															
48			0.51	0.65	0.36	0.46	0.43	0.38	0.28	0.33	0.16	0.28														
47				0.66	0.45	0.45	0.45	0.15	0.50	0.26	0.27	0.31	0.26													
46				0.53	0.40	0.46	0.55	0.49	0.34	0.26	0.22	0.26	0.34													
45				0.43	0.60	0.55	0.57	0.50	0.51	0.51	0.40	0.19	0.25													
44				0.59	0.36	0.33	0.42	0.52	0.56	0.58	0.21	0.23	0.08													
43				0.39	0.21	0.71	0.28	0.24	0.53	0.42	0.21	0.18	0.05													
42				0.36	0.48	0.41	0.25	0.52	0.46	0.26	0.38	0.22	0.13													
41				0.28	0.37	0.43	0.21	0.33	0.30	0.50	0.40	0.19	0.13													
40				0.34	0.22	0.29	0.30	0.43	0.28	0.21	0.35	0.27	0.13													
39				0.38	0.30	0.23	0.21	0.38	0.36	0.32	0.31	0.38	0.42													
38					0.28	0.35	0.36	0.39	0.28	0.34	0.43	0.45	0.56	0.74												
37						0.16	0.29	0.28	0.32	0.40	0.47	0.56	0.70	0.50	0.43											
36						0.31	0.37	0.32	0.35	0.40	0.44	0.44	0.43	0.53	0.55											
35							0.29	0.39	0.37	0.37	0.33	0.40	0.33	0.46	0.54	0.63										
34									0.25	0.30	0.24	0.46	0.44	0.51	0.56	0.72	0.75	0.28								
33										0.27	0.25	0.35	0.45	0.57	0.57	0.74	0.83	0.65	0.40							
32											0.25	0.33	0.33	0.42	0.56	0.60	0.76	0.59	0.42	0.28						
31											0.04	0.21	0.27	0.30	0.56	0.51	0.66	0.57	0.50	0.39						
30												0.12	0.13	0.22	0.40	0.47	0.43	0.38	0.49	0.47	0.45					
29													0.08	0.19	0.29	0.23	0.43	0.30	0.39	0.43	0.49	0.59				
28													-0.03	0.04	0.20	0.22	0.19	0.37	0.42	0.33	0.45	0.48				
27														-0.08	0.04	0.06	0.07	0.32	0.25	0.38	0.37	0.49	0.49			
26															-0.09	-0.01	0.27	0.07	0.26	0.20	0.44	0.37	0.49	0.52		
25															-0.15	0.00	-0.03	0.11	0.18	0.06	0.14	0.27	0.39	0.47		
24																	-0.01	-0.04	0.00	0.17	0.07	0.25	0.33	0.42	0.43	0.48
23																	-0.14	-0.10	-0.04	0.00	0.05	0.09	0.26	0.19	0.40	0.43
22																	-0.22	-0.03	-0.10	-0.11	0.18	0.04	0.12	0.25	0.18	0.35
21																	-0.26	-0.34	-0.10	-0.13	-0.22	-0.02	0.02	0.02	0.23	0.26

Chart 16.—East component surface wind stress for April.

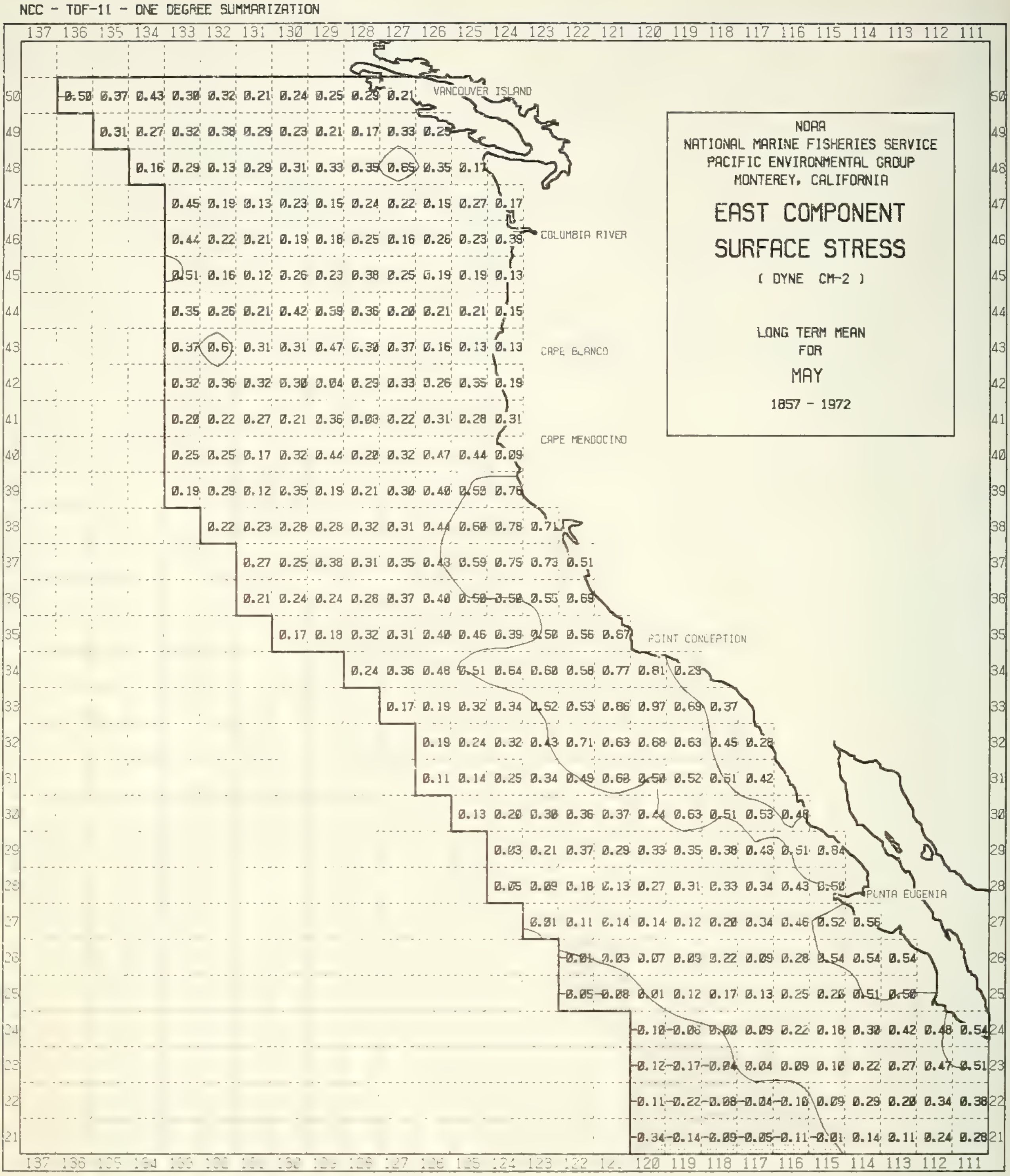
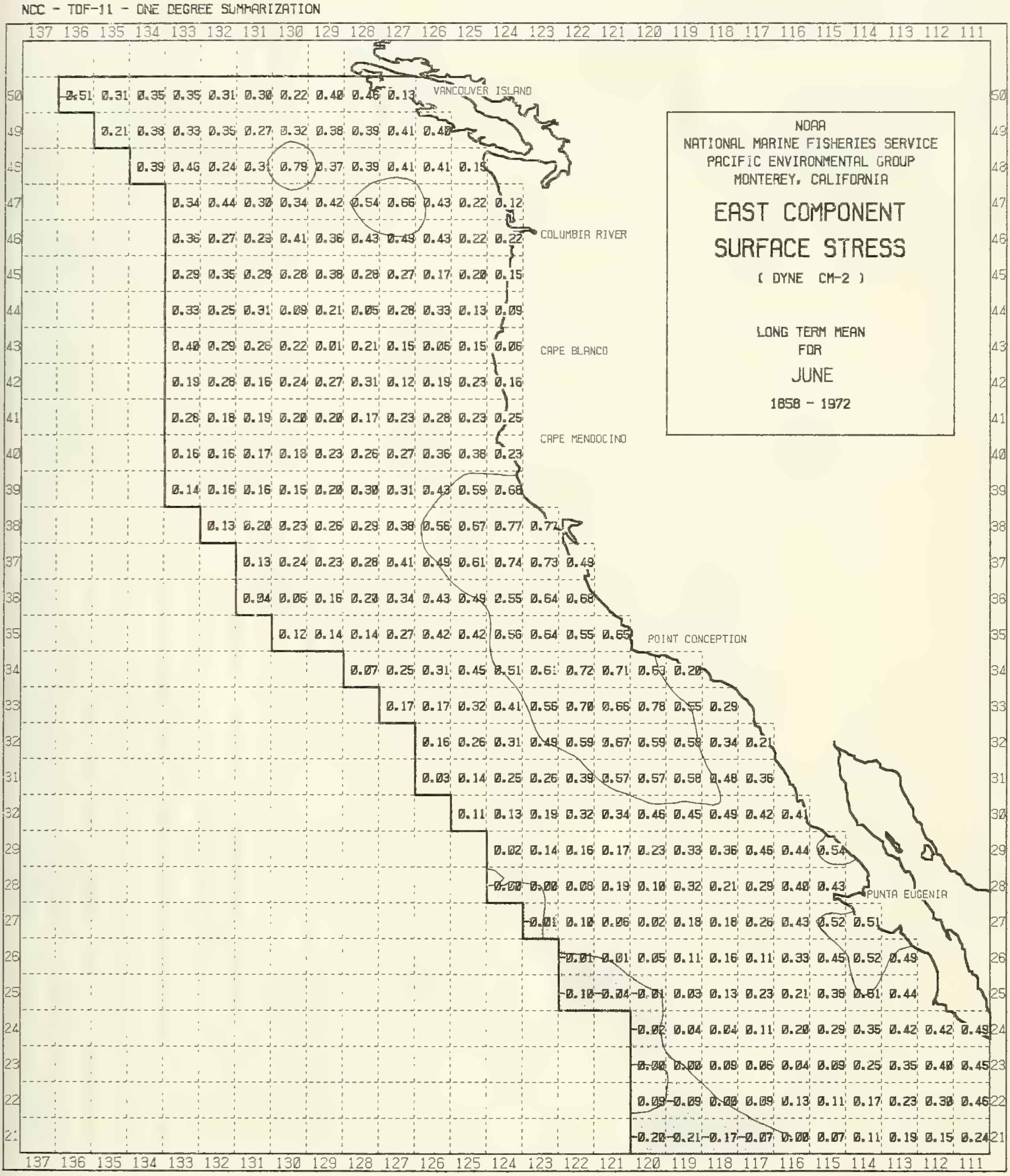
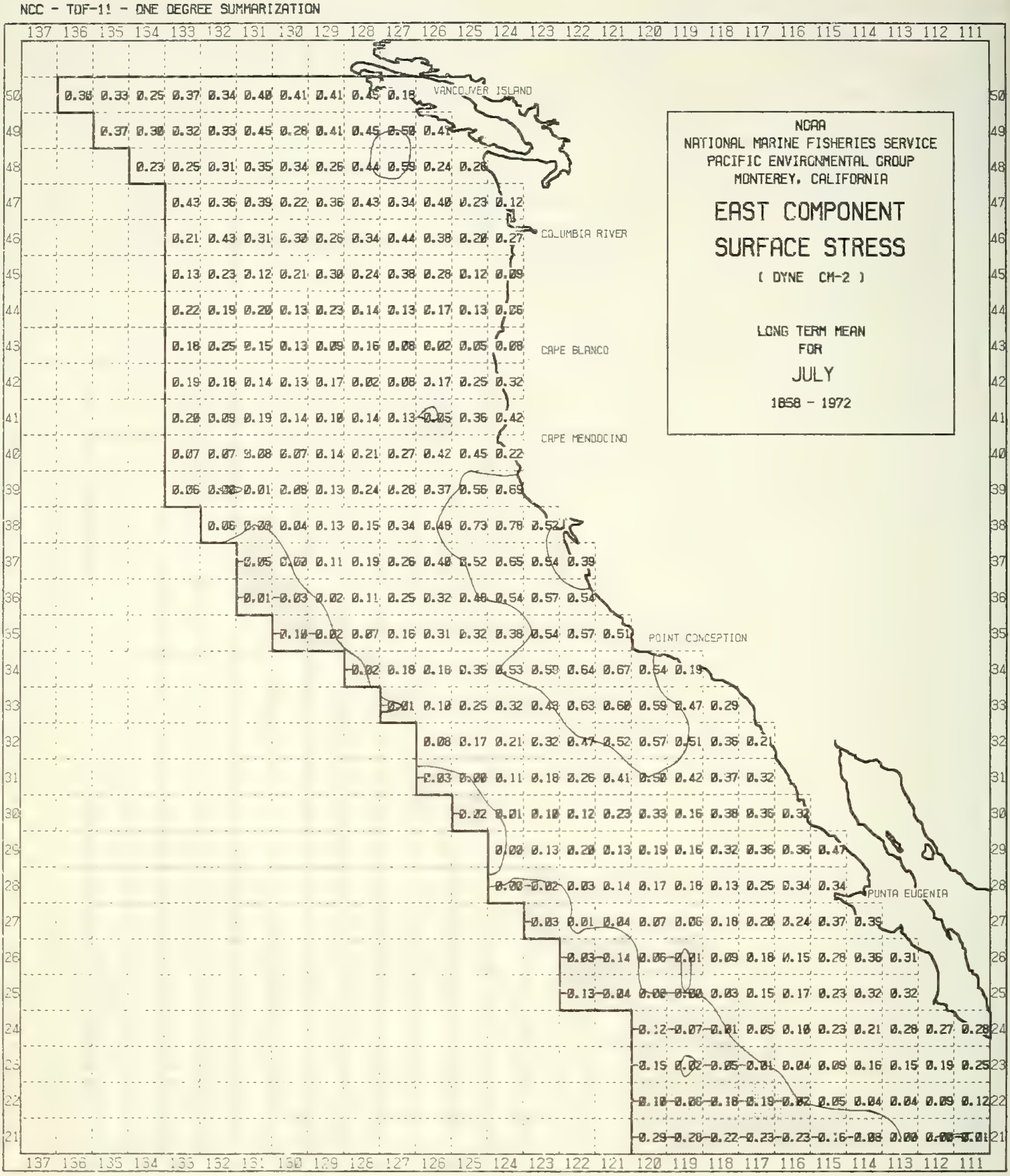


Chart 17.—East component surface wind stress for May.



	136	135	134	133	132	131	130	129	128	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112	111
50	-0.51	0.31	0.35	0.35	0.31	0.30	0.22	0.40	0.46	0.13																
49		0.21	0.38	0.33	0.35	0.27	0.32	0.38	0.39	0.41	0.40															
48			0.39	0.46	0.24	0.31	0.79	0.37	0.39	0.41	0.41	0.15														
47				0.34	0.44	0.30	0.34	0.42	0.54	0.66	0.43	0.22	0.12													
46				0.36	0.27	0.23	0.41	0.36	0.43	0.49	0.43	0.22	0.22													
45				0.29	0.35	0.28	0.28	0.38	0.28	0.27	0.17	0.20	0.15													
44				0.33	0.25	0.31	0.09	0.21	0.05	0.28	0.33	0.13	0.09													
43				0.40	0.29	0.26	0.22	0.01	0.21	0.15	0.06	0.15	0.06													
42				0.19	0.28	0.16	0.24	0.27	0.31	0.12	0.19	0.23	0.16													
41				0.28	0.18	0.19	0.20	0.20	0.17	0.23	0.28	0.23	0.25													
40				0.16	0.16	0.17	0.18	0.23	0.26	0.27	0.36	0.38	0.23													
39				0.14	0.16	0.16	0.15	0.20	0.30	0.31	0.43	0.59	0.68													
38					0.13	0.20	0.23	0.26	0.29	0.38	0.56	0.67	0.77	0.77												
37						0.13	0.24	0.23	0.28	0.41	0.49	0.61	0.74	0.73	0.49											
36						0.04	0.06	0.16	0.20	0.34	0.43	0.49	0.55	0.64	0.68											
35							0.12	0.14	0.14	0.27	0.42	0.42	0.56	0.64	0.55	0.65										
34									0.07	0.25	0.31	0.45	0.51	0.61	0.72	0.71	0.63	0.20								
33										0.17	0.17	0.32	0.41	0.56	0.70	0.66	0.78	0.55	0.29							
32											0.16	0.26	0.31	0.49	0.59	0.67	0.59	0.58	0.34	0.21						
31											0.03	0.14	0.25	0.26	0.39	0.57	0.57	0.58	0.48	0.36						
30												0.11	0.13	0.19	0.32	0.34	0.46	0.45	0.49	0.42	0.41					
29													0.02	0.14	0.16	0.17	0.23	0.33	0.36	0.46	0.44	0.54				
28													-0.00	0.00	0.08	0.19	0.10	0.32	0.21	0.29	0.40	0.43				
27														-0.01	0.10	0.06	0.02	0.18	0.18	0.26	0.43	0.52	0.51			
26															-0.01	0.01	0.05	0.11	0.16	0.11	0.33	0.45	0.52	0.49		
25															-0.10	-0.04	-0.01	0.03	0.13	0.23	0.21	0.38	0.51	0.44		
24																	-0.02	0.04	0.04	0.11	0.20	0.29	0.35	0.42	0.42	0.49
23																	-0.00	0.00	0.09	0.06	0.04	0.09	0.25	0.35	0.40	0.45
22																	0.09	-0.09	0.00	0.09	0.13	0.11	0.17	0.23	0.30	0.46
21																	-0.20	-0.21	-0.17	-0.07	0.00	0.07	0.11	0.19	0.15	0.24

Chart 18.—East component surface wind stress for June.



	137	136	135	134	133	132	131	130	129	128	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112	111
50		0.36	0.33	0.25	0.37	0.34	0.40	0.41	0.41	0.45	0.18																
49			0.37	0.30	0.32	0.33	0.45	0.28	0.41	0.45	0.50	0.41															
48				0.23	0.25	0.31	0.35	0.34	0.26	0.44	0.59	0.24	0.26														
47					0.43	0.36	0.39	0.22	0.36	0.43	0.34	0.40	0.23	0.12													
46					0.21	0.43	0.31	0.30	0.26	0.34	0.44	0.38	0.20	0.27													
45					0.13	0.23	0.12	0.21	0.30	0.24	0.38	0.28	0.12	0.09													
44					0.22	0.19	0.20	0.13	0.23	0.14	0.13	0.17	0.13	0.06													
43					0.18	0.25	0.15	0.13	0.09	0.16	0.08	0.02	0.05	0.08													
42					0.19	0.18	0.14	0.13	0.17	0.02	0.08	0.17	0.25	0.32													
41					0.20	0.09	0.19	0.14	0.10	0.14	0.13	0.05	0.36	0.42													
40					0.07	0.07	0.08	0.07	0.14	0.21	0.27	0.42	0.45	0.22													
39					0.06	0.00	0.01	0.08	0.13	0.24	0.28	0.37	0.56	0.69													
38						0.06	0.00	0.04	0.13	0.15	0.34	0.48	0.73	0.78	0.52												
37							-0.05	0.00	0.11	0.19	0.26	0.40	0.52	0.65	0.54	0.39											
36							-0.01	-0.03	0.02	0.11	0.25	0.32	0.48	0.54	0.57	0.54											
35								-0.10	-0.02	0.07	0.16	0.31	0.32	0.38	0.54	0.57	0.51										
34										-0.02	0.18	0.18	0.35	0.53	0.59	0.64	0.67	0.54	0.19								
33											-0.01	0.10	0.25	0.32	0.43	0.63	0.60	0.59	0.47	0.29							
32												0.08	0.17	0.21	0.32	0.47	0.52	0.57	0.51	0.36	0.21						
31												-0.03	0.00	0.11	0.18	0.26	0.41	0.50	0.42	0.37	0.32						
30													-0.22	0.01	0.10	0.12	0.23	0.33	0.16	0.38	0.36	0.32					
29														0.00	0.13	0.20	0.13	0.19	0.16	0.32	0.36	0.36	0.47				
28														-0.00	-0.02	0.03	0.14	0.17	0.18	0.13	0.25	0.34	0.34				
27															-0.03	0.01	0.04	0.07	0.06	0.18	0.20	0.24	0.37	0.39			
26																-0.03	-0.14	0.06	-0.01	0.09	0.18	0.15	0.28	0.36	0.31		
25																-0.13	-0.04	0.00	0.00	0.03	0.15	0.17	0.23	0.32	0.32		
24																		-0.12	-0.07	-0.01	0.05	0.10	0.23	0.21	0.28	0.27	0.28
23																		-0.15	0.02	-0.05	-0.01	0.04	0.09	0.16	0.15	0.19	0.25
22																		-0.10	-0.06	-0.18	-0.19	-0.02	0.05	0.04	0.04	0.09	0.12
21																		-0.29	-0.20	-0.22	-0.23	-0.23	-0.16	-0.08	0.00	0.00	-0.01

Chart 19.—East component surface wind stress for July.

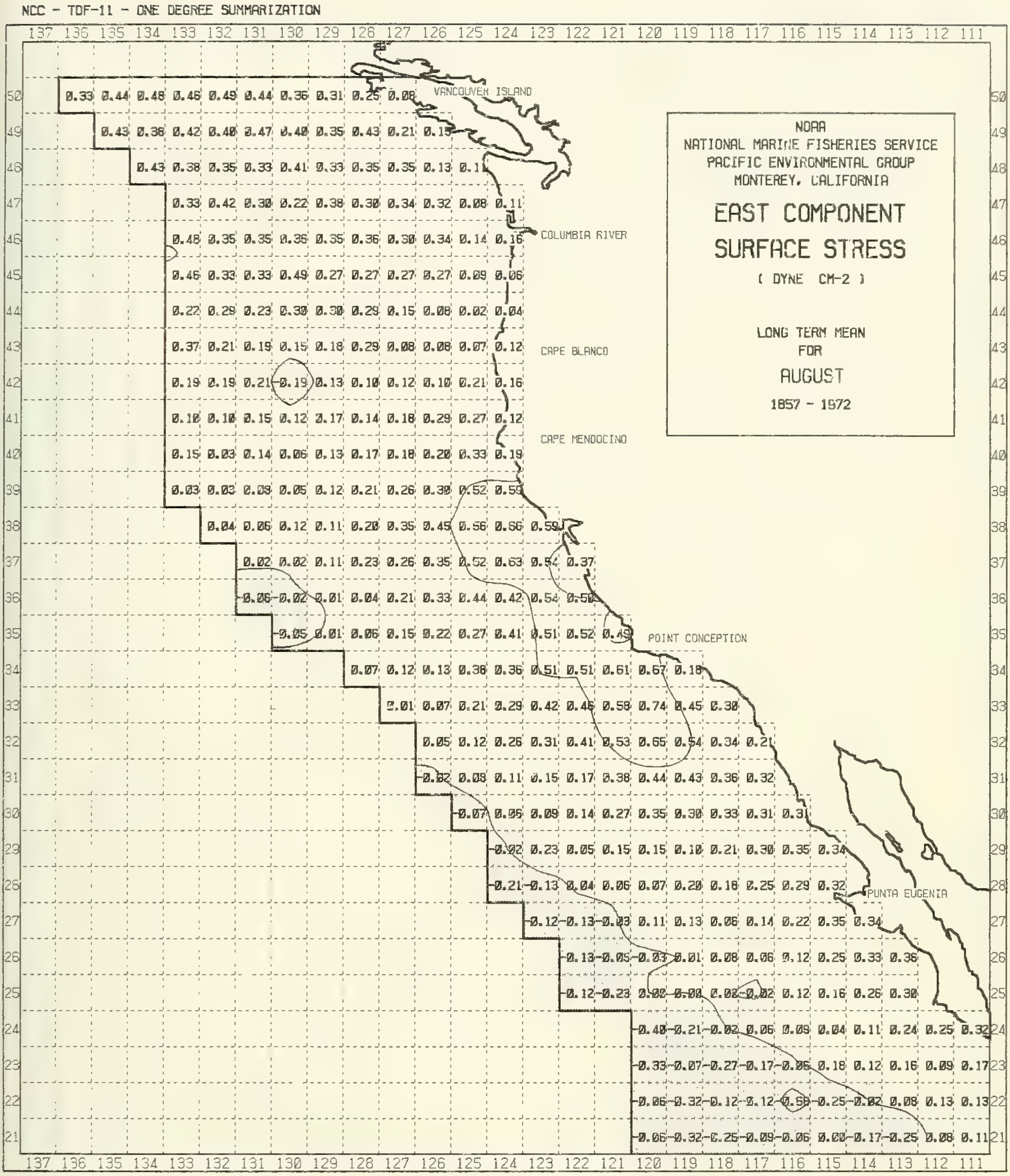
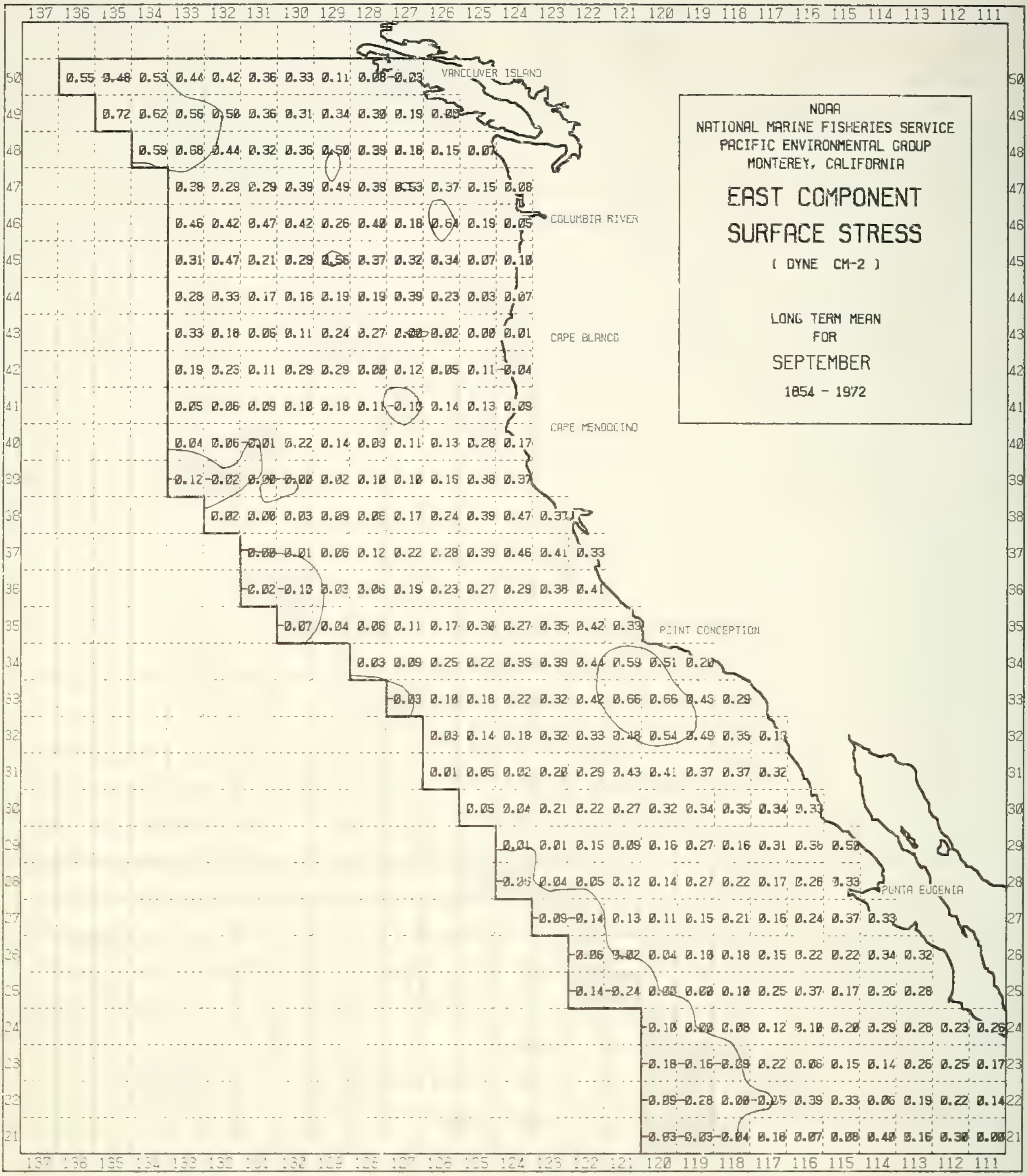


Chart 20.—East component surface wind stress for August.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION



NOAA
NATIONAL MARINE FISHERIES SERVICE
PACIFIC ENVIRONMENTAL GROUP
MONTEREY, CALIFORNIA

EAST COMPONENT
SURFACE STRESS
(DYNE CM-2)

LONG TERM MEAN
FOR
SEPTEMBER
1854 - 1972

Chart 21.—East component surface wind stress for September.

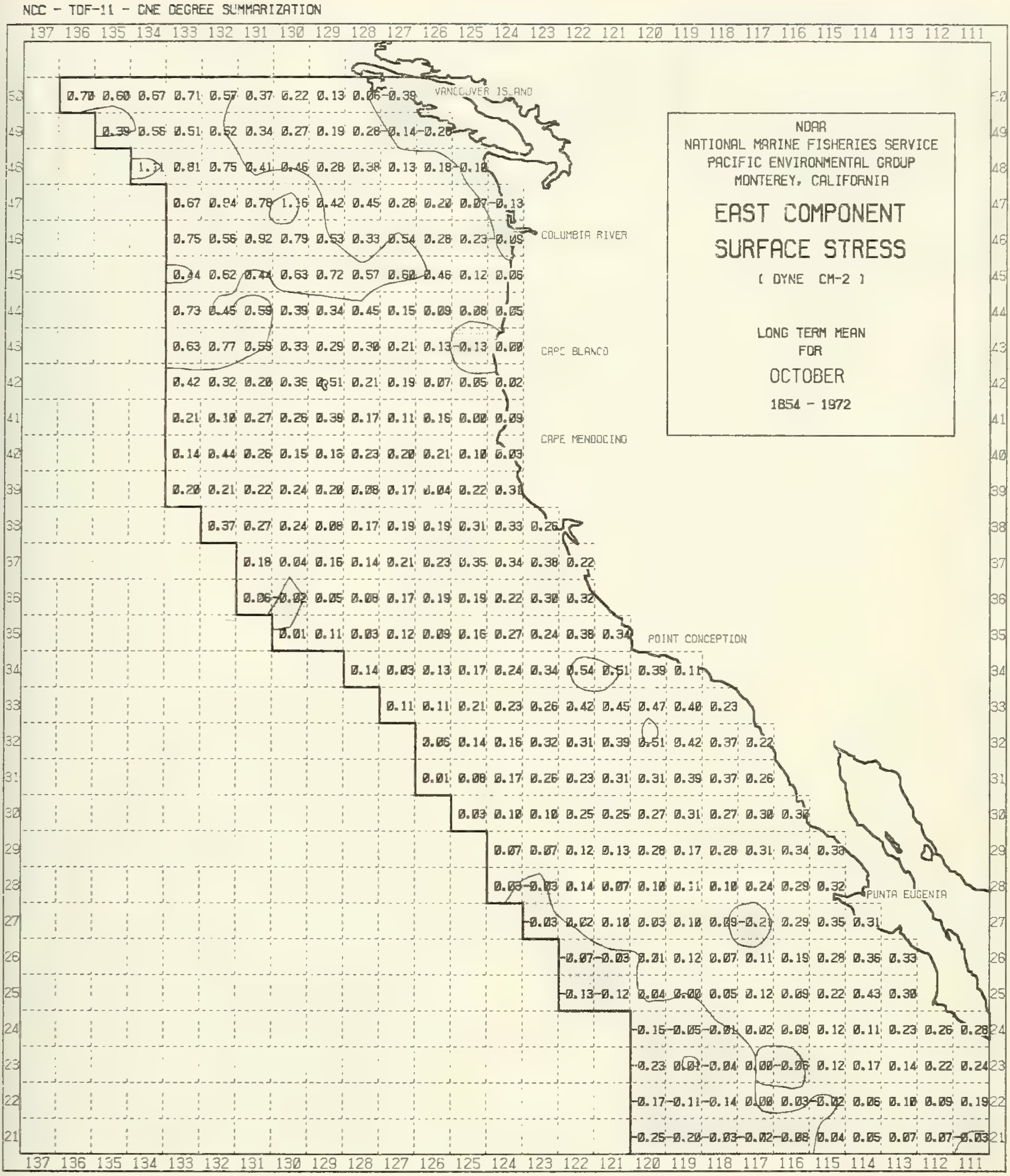


Chart 22.—East component surface wind stress for October.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION

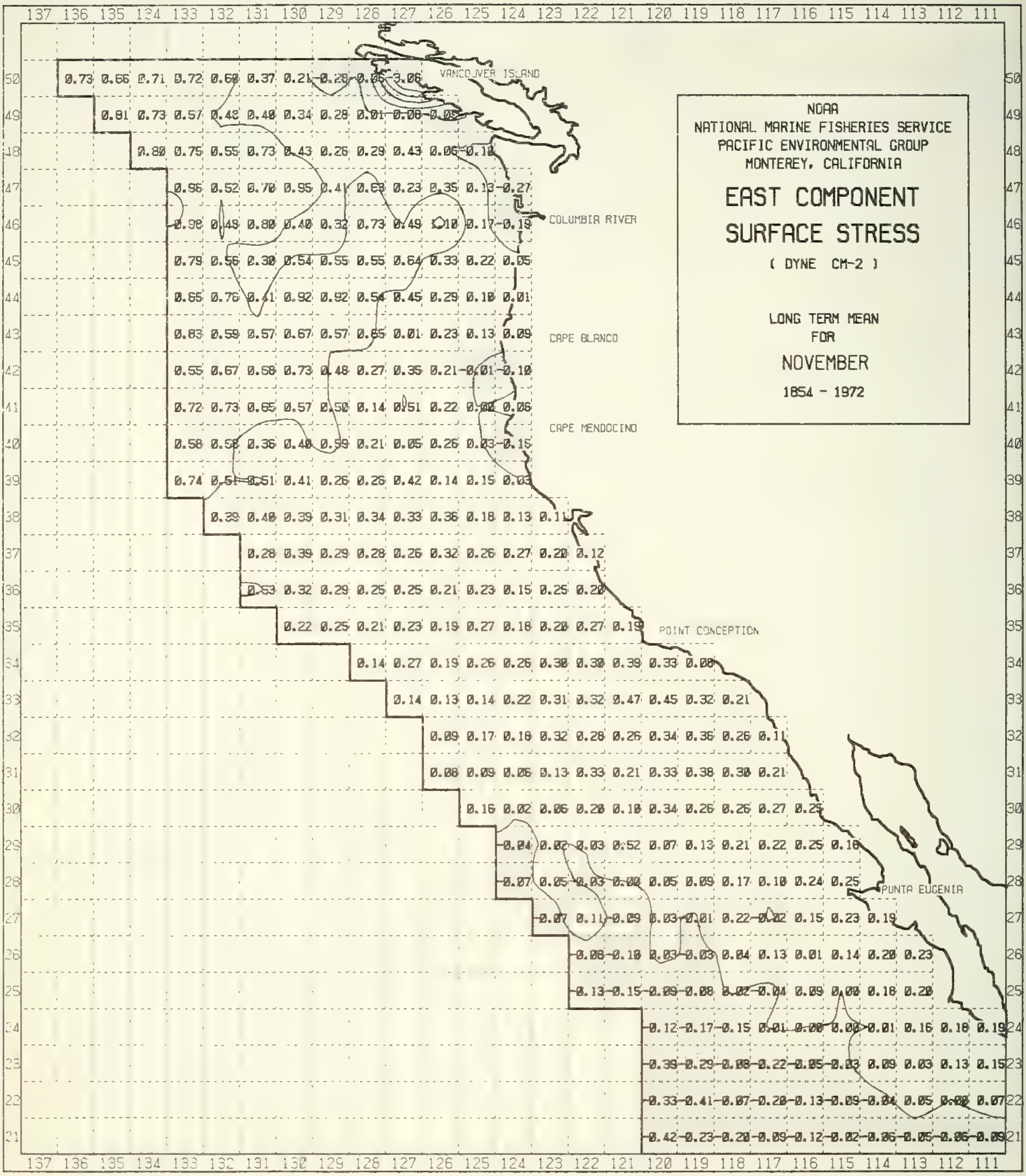


Chart 23.—East component surface wind stress for November.

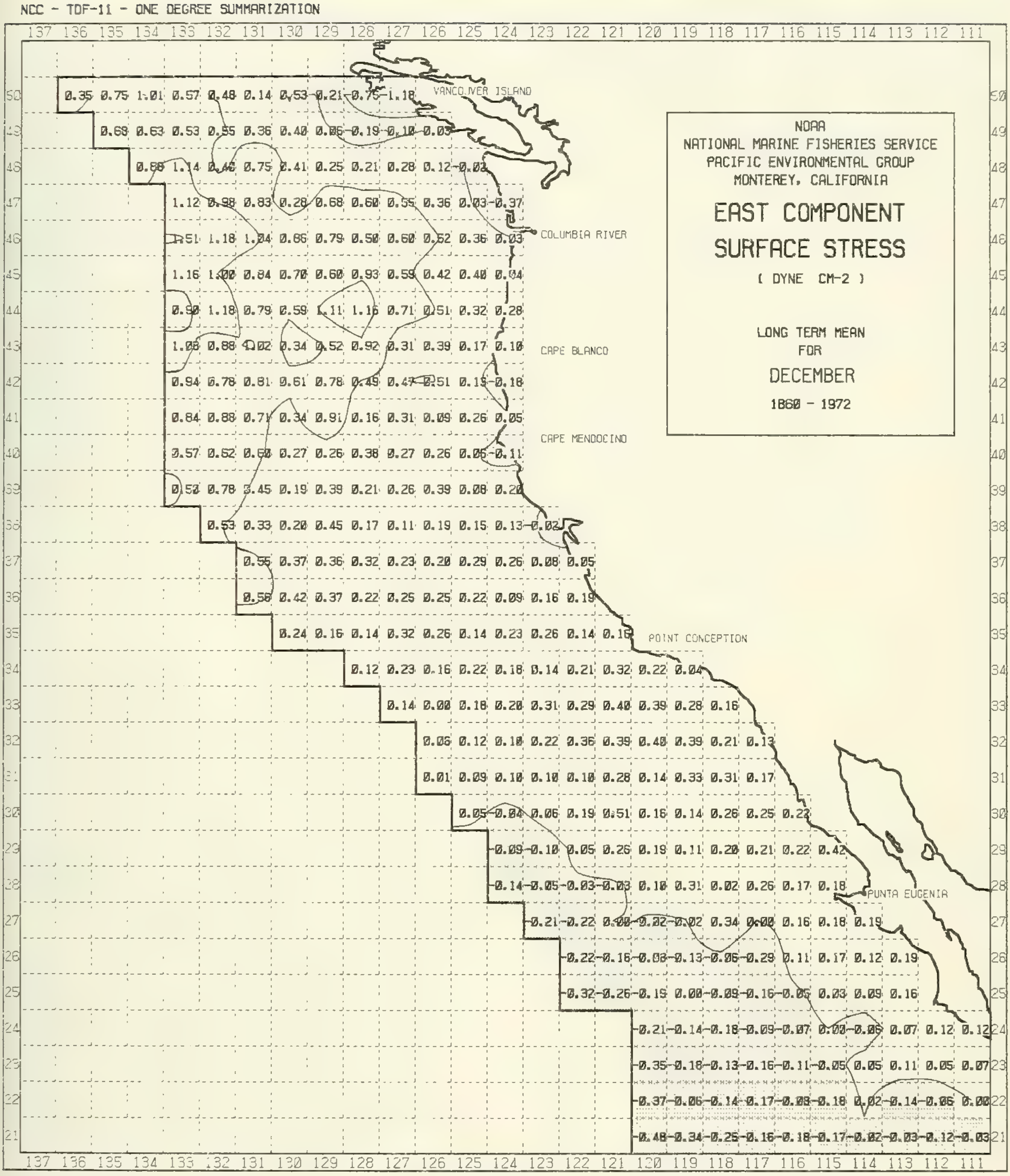


Chart 24.—East component surface wind stress for December.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION

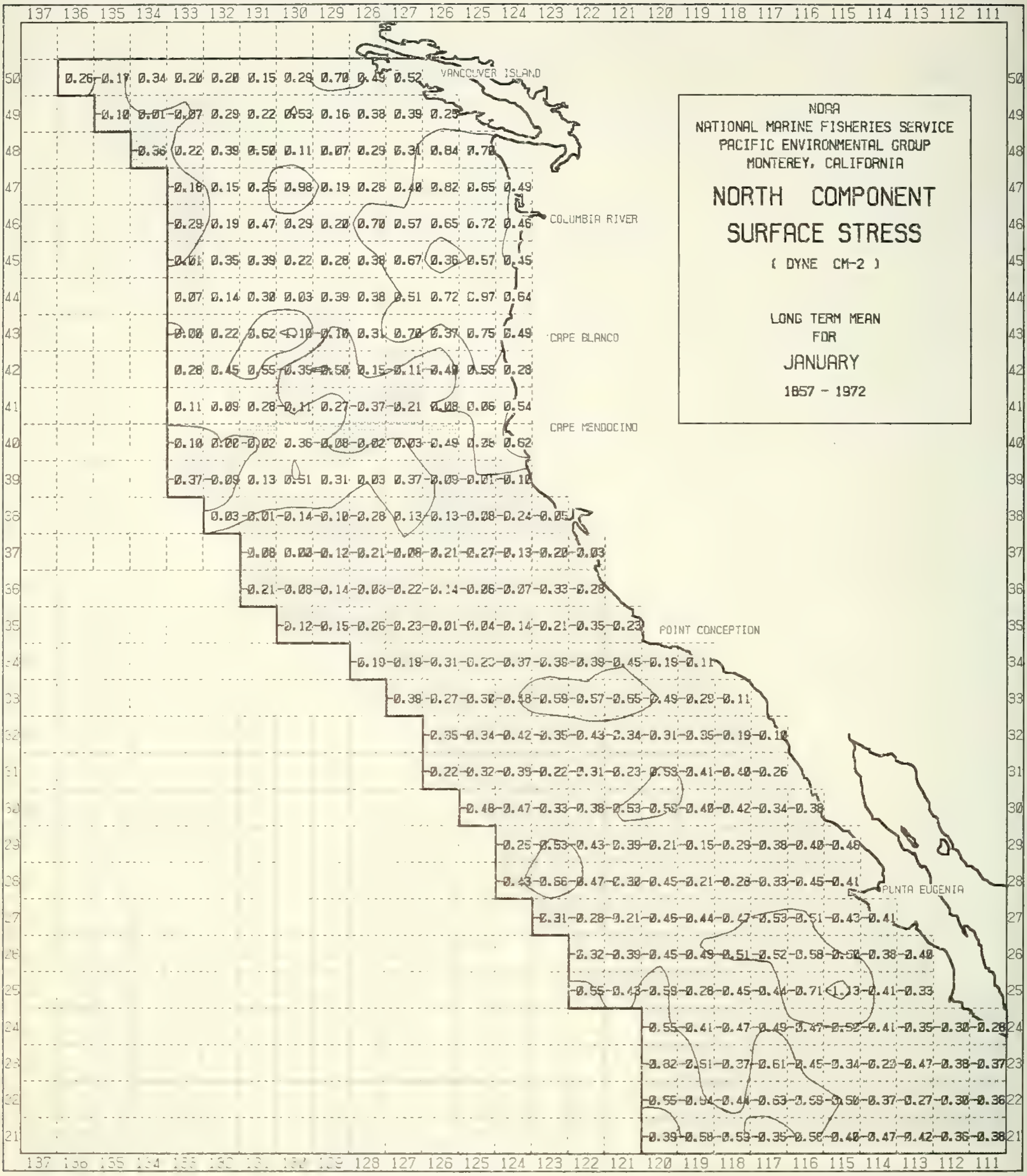


Chart 25.—North component surface wind stress for January.

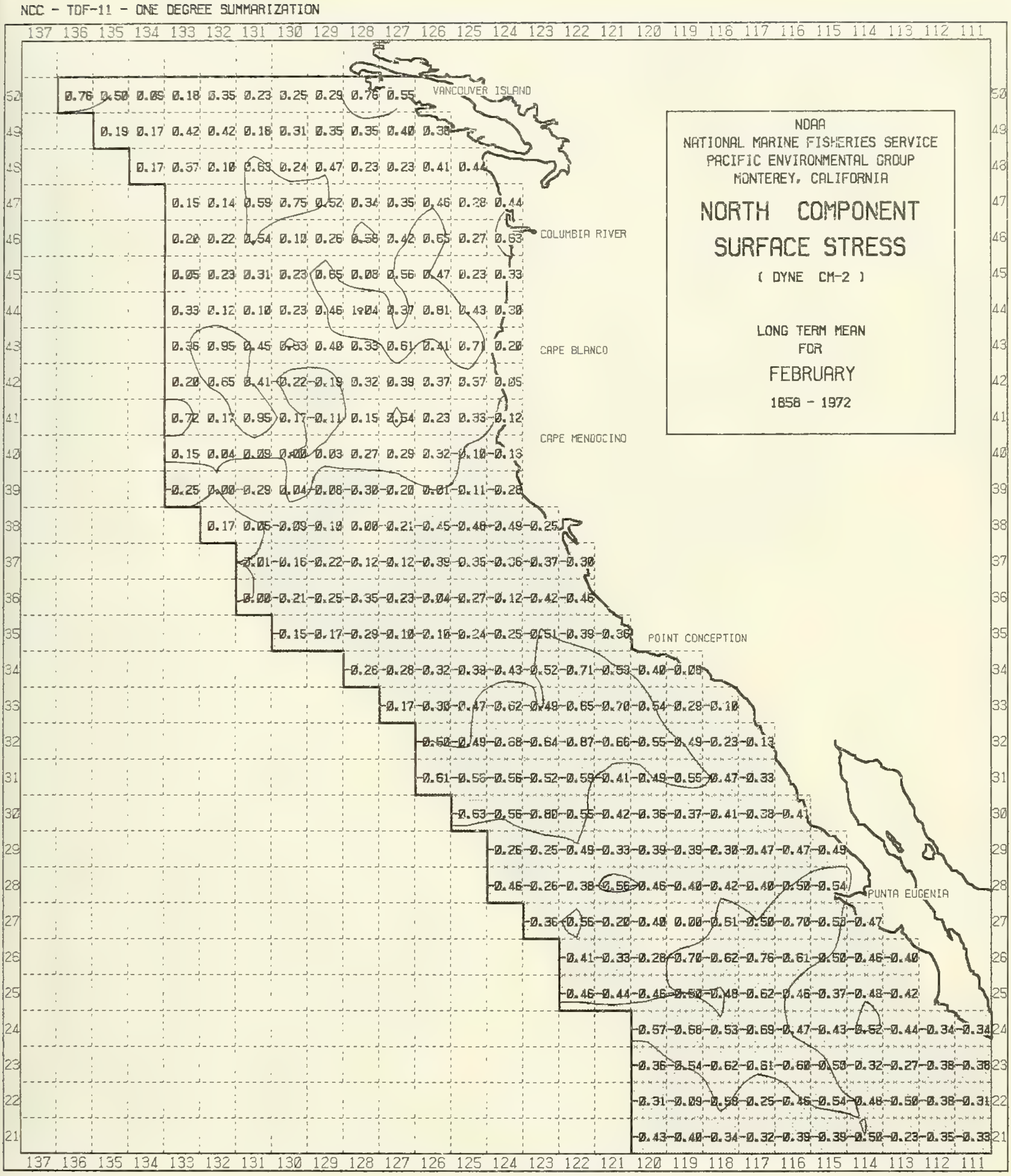


Chart 26.—North component surface wind stress for February.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION

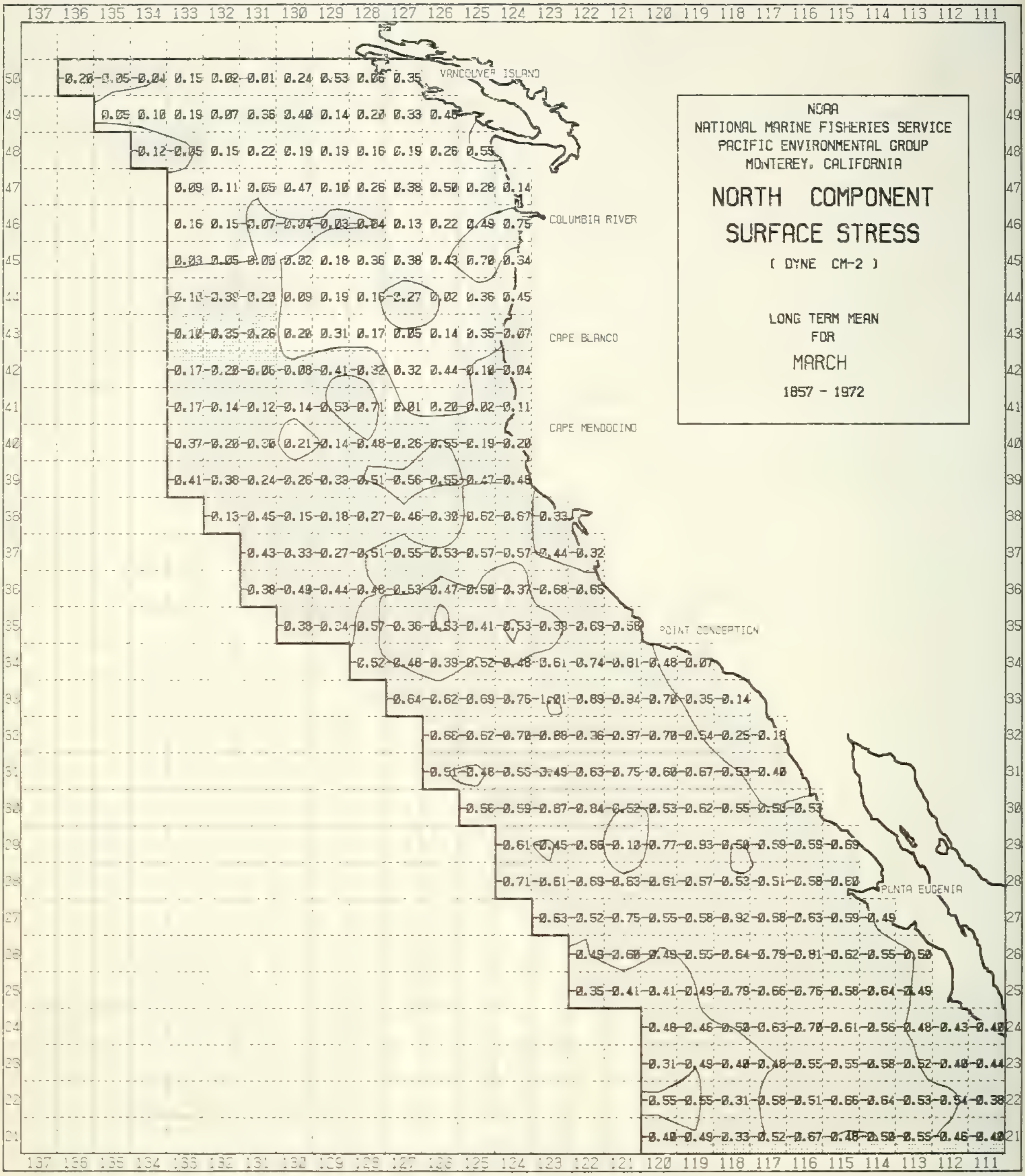


Chart 27.—North component surface wind stress for March.

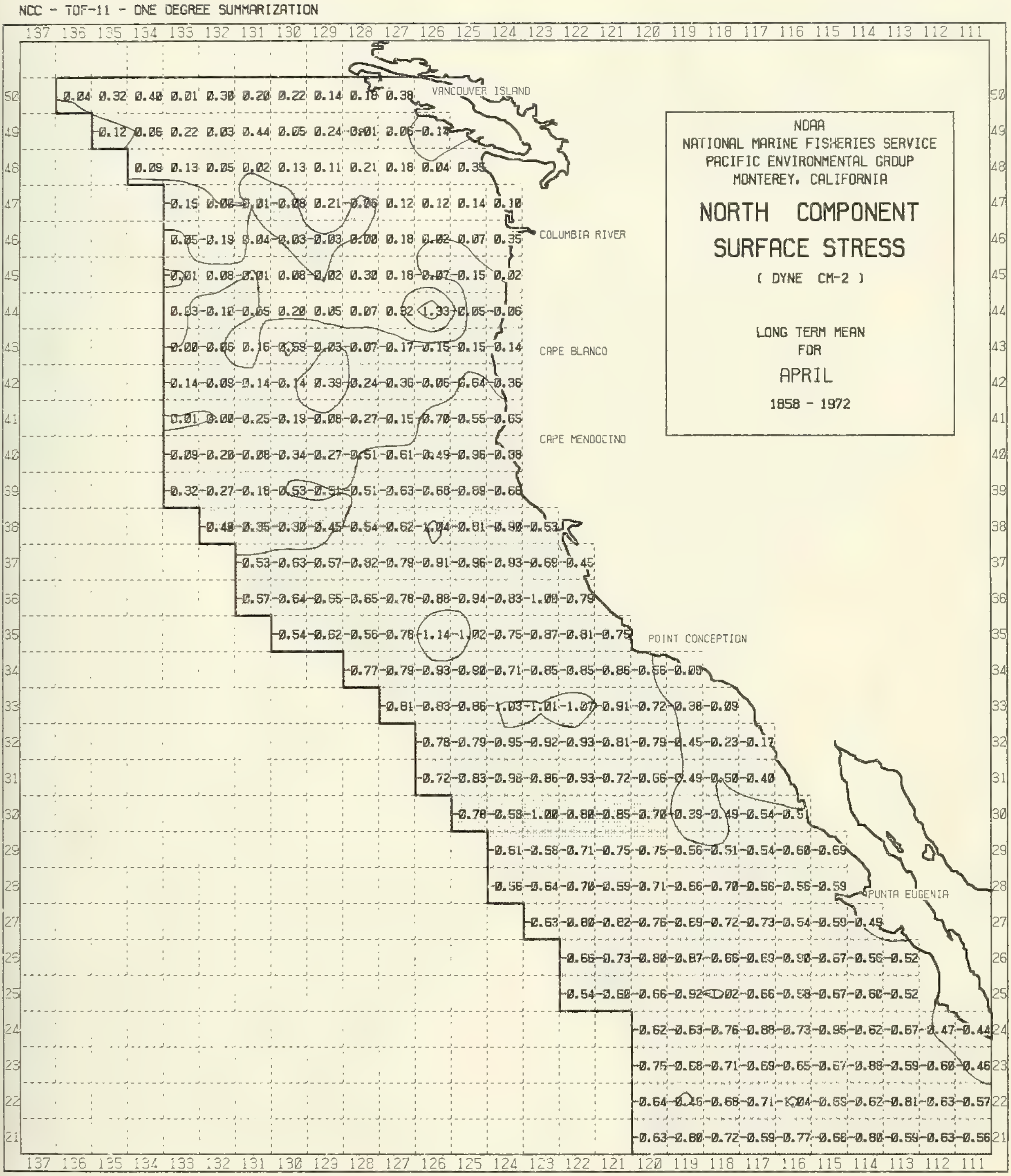


Chart 28.—North component surface wind stress for April.

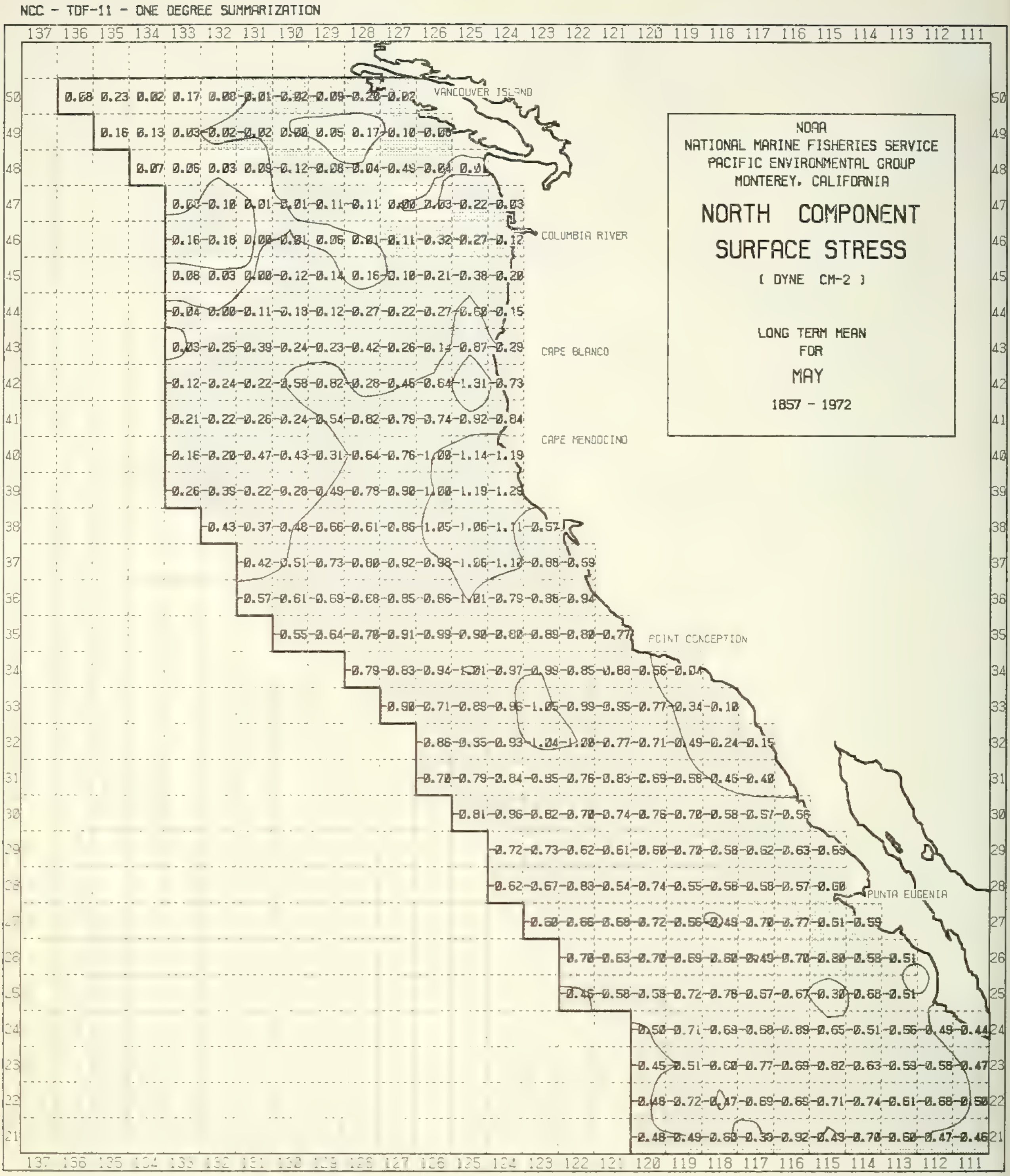


Chart 29.—North component surface wind stress for May.

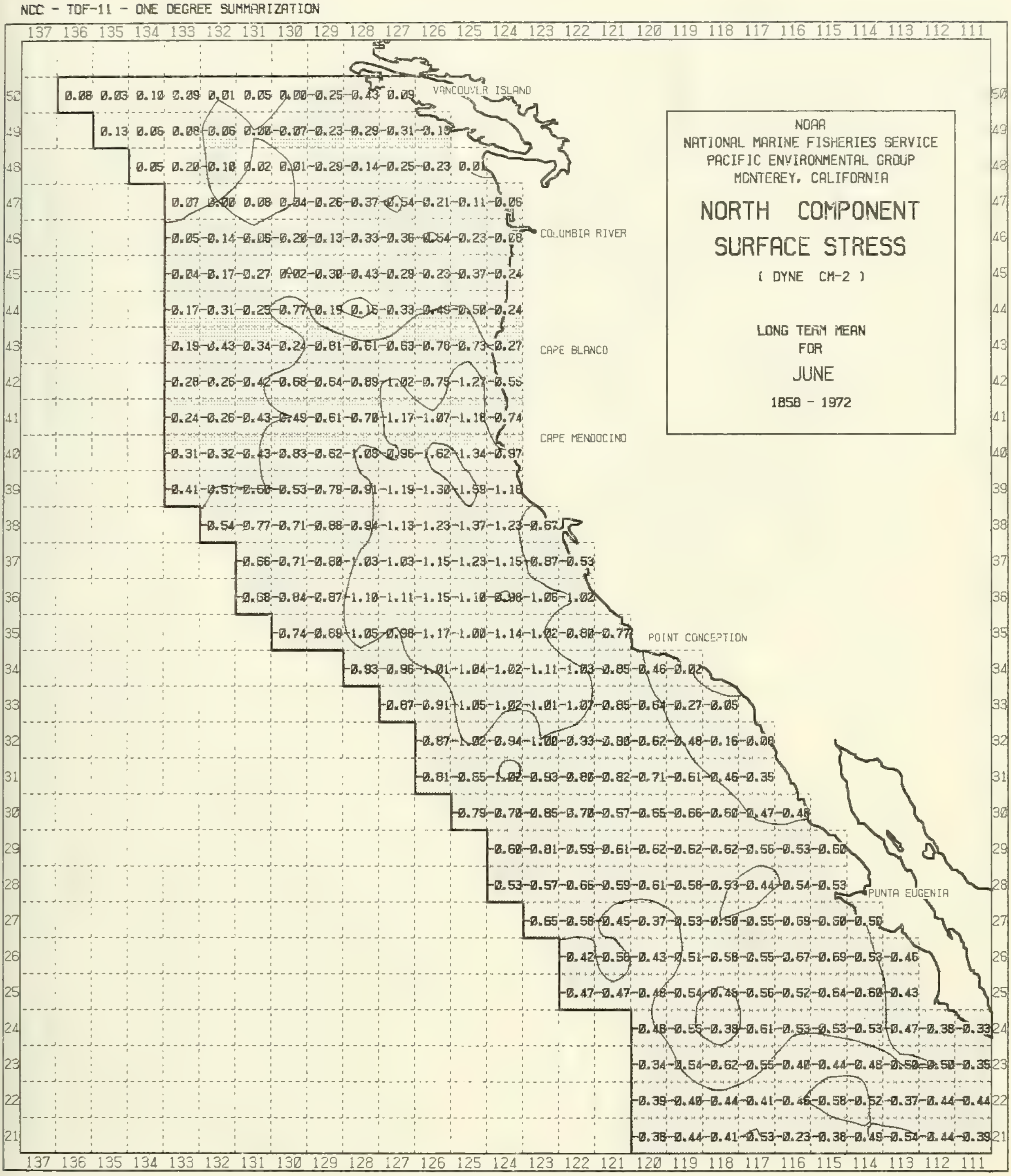


Chart 30.—North component surface wind stress for June.

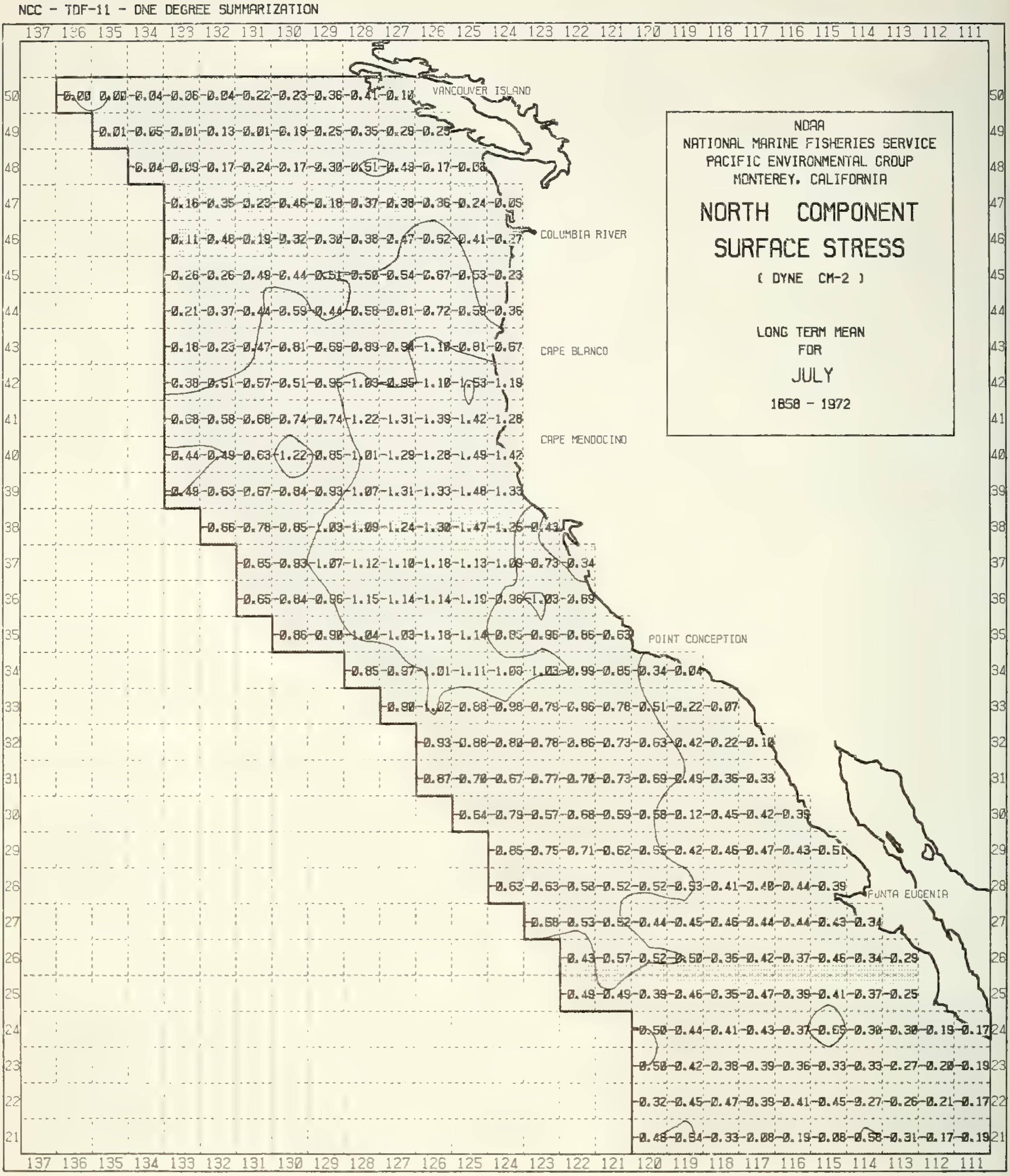


Chart 31.—North component surface wind stress for July.

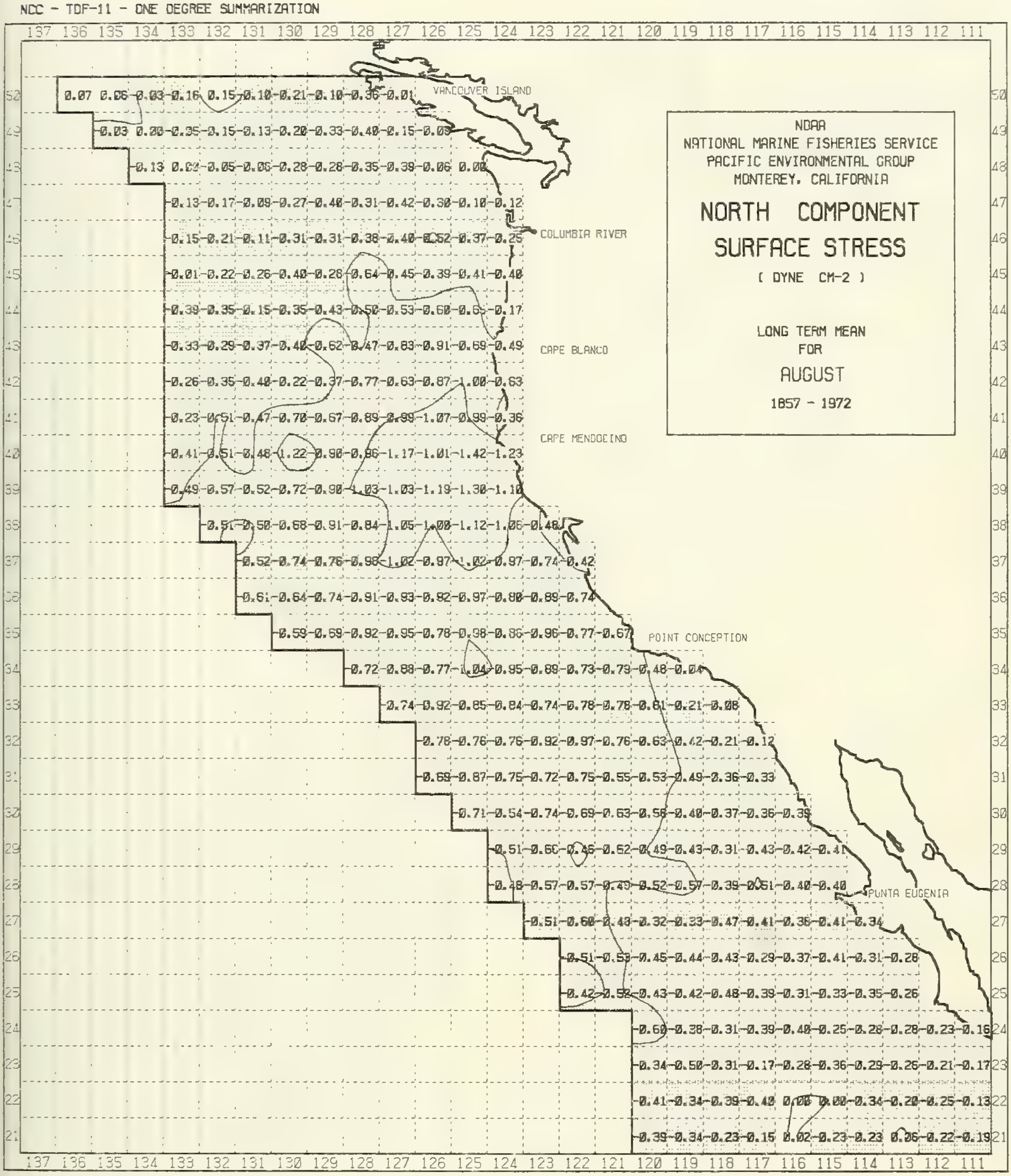


Chart 32.—North component surface wind stress for August.

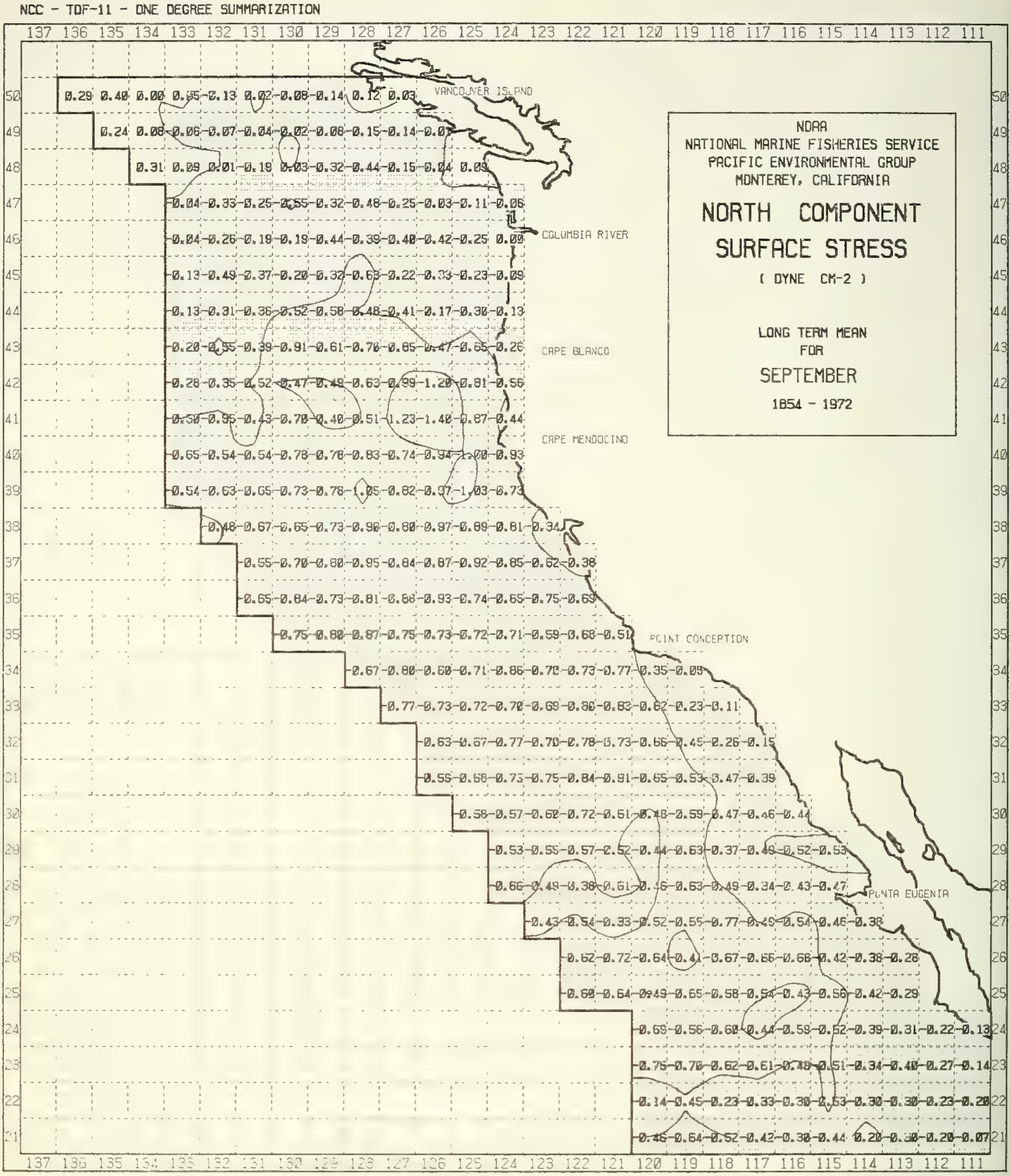


Chart 33.—North component surface wind stress for September.

NCC - TDF-11 - ONE DEGREE SUMMARIZATION

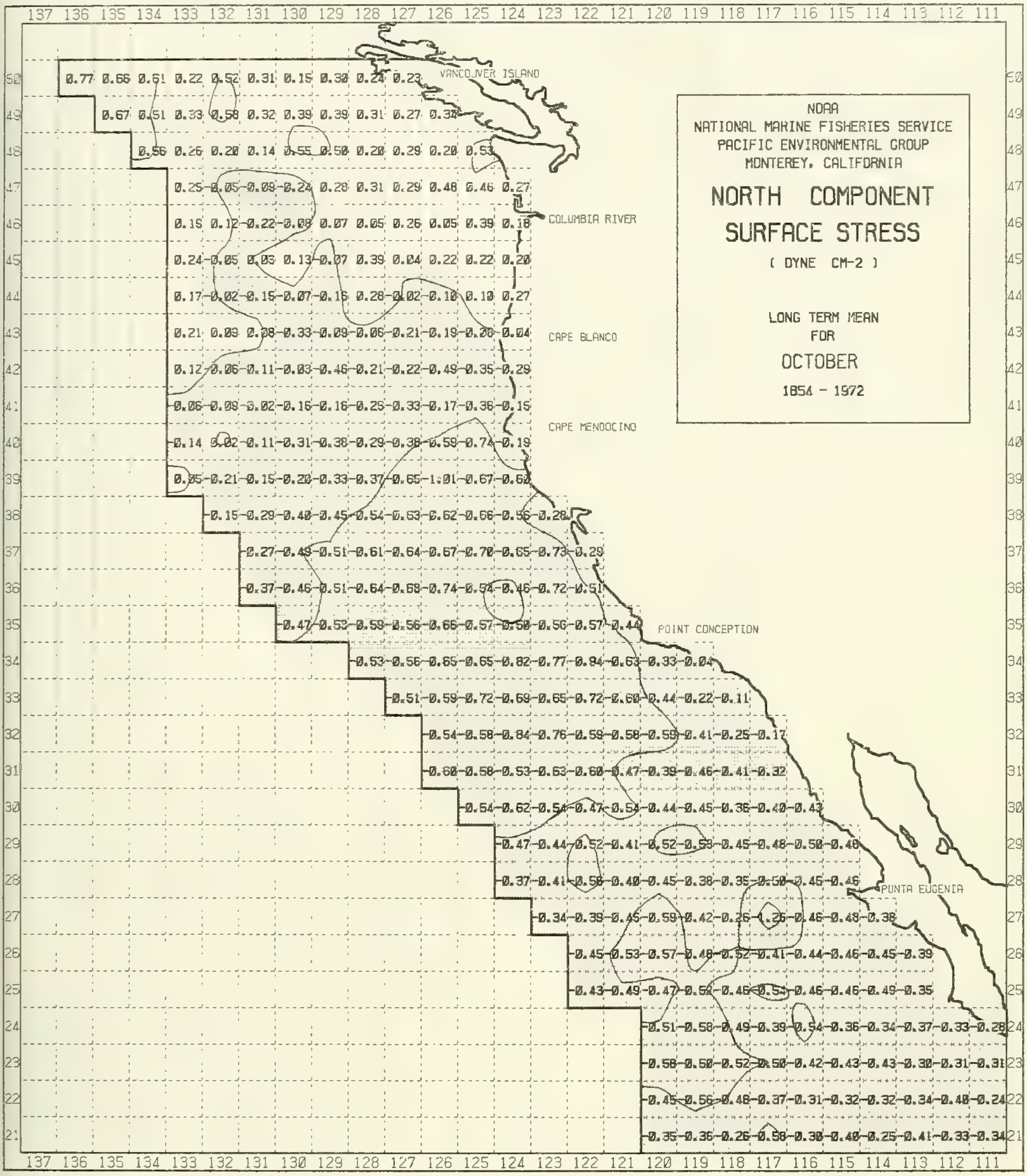


Chart 34.—North component surface wind stress for October.

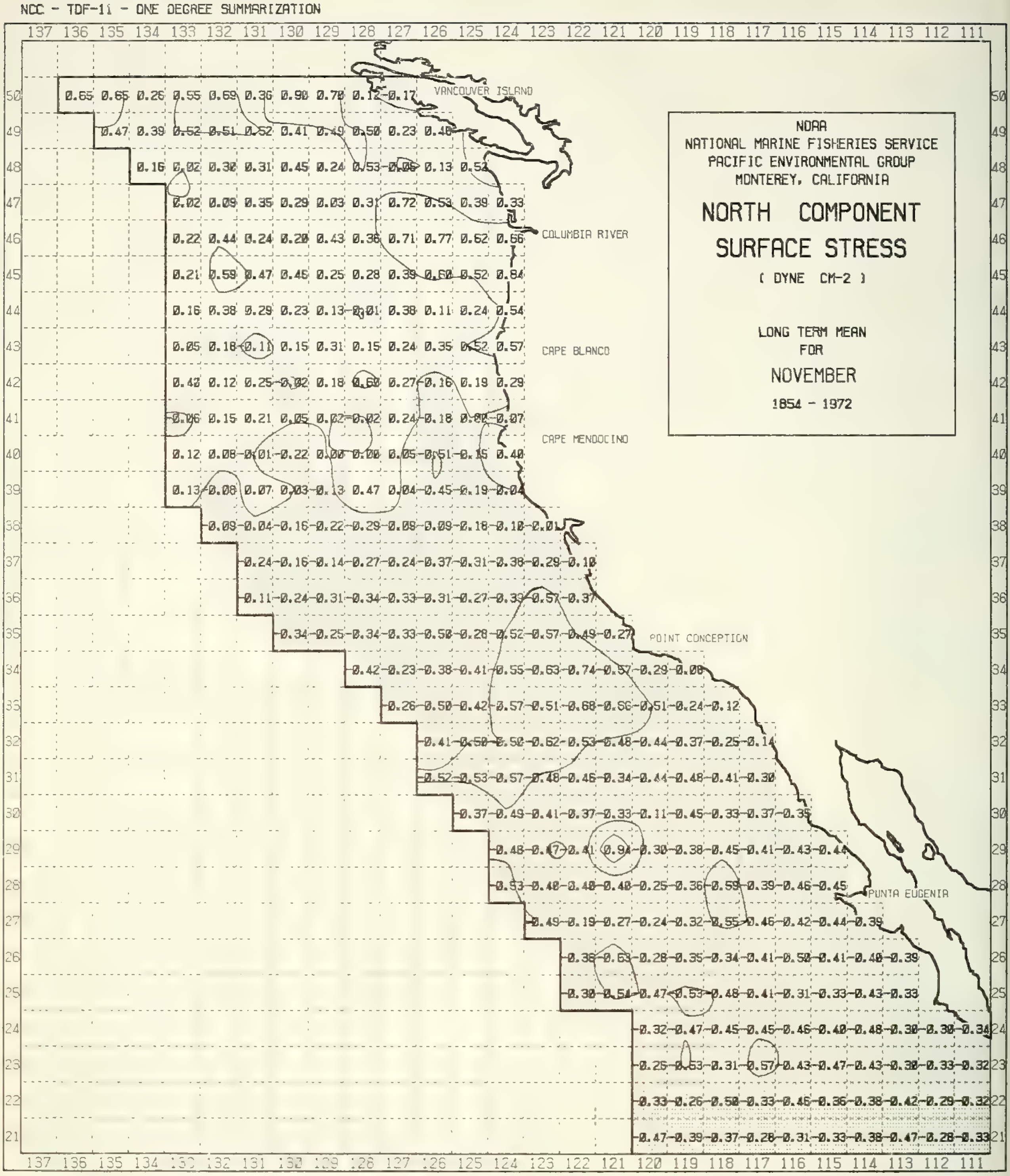


Chart 35.—North component surface wind stress for November.

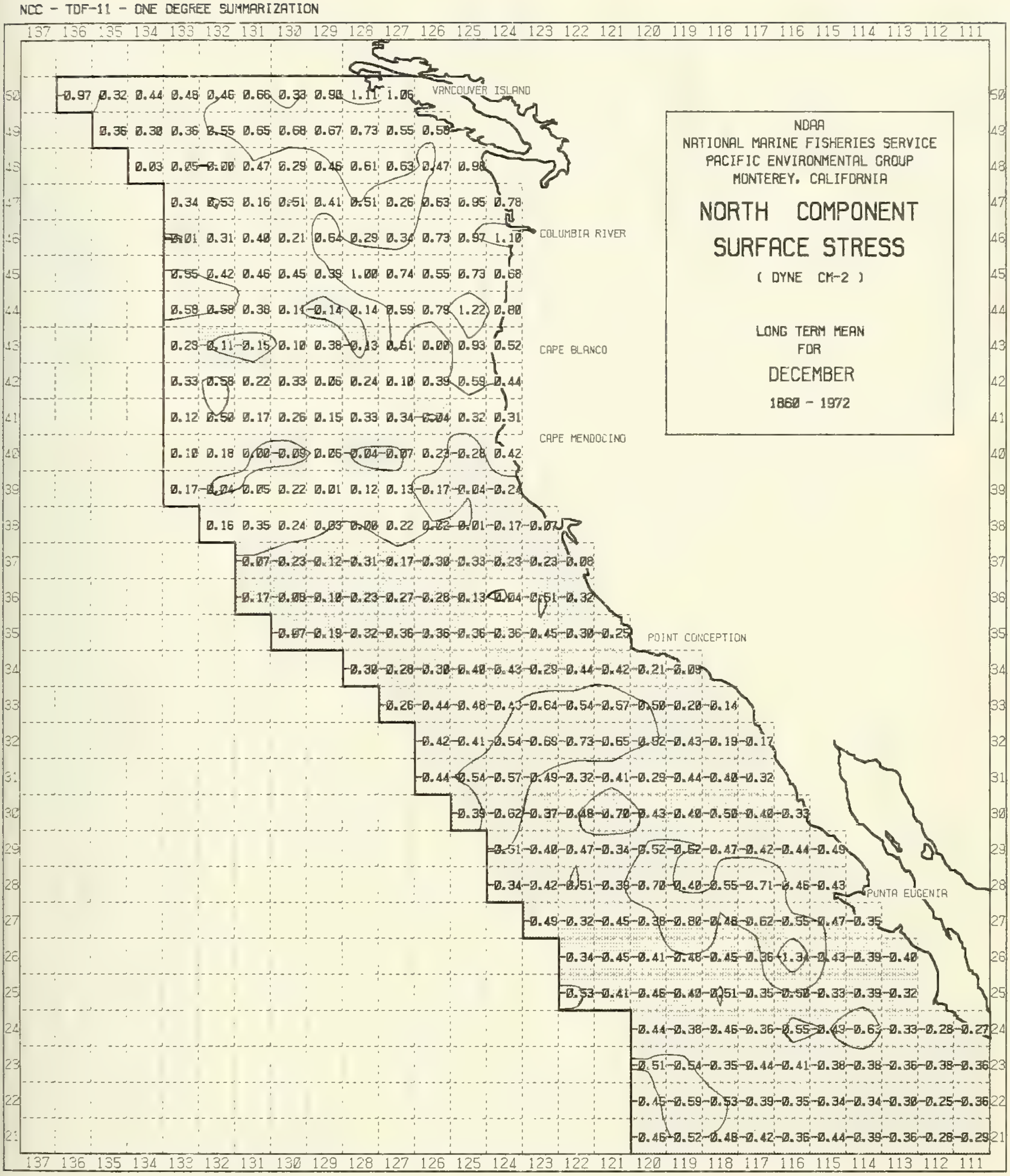


Chart 36.—North component surface wind stress for December.

APPENDIX II

Standard Errors of the Means

The following tables list the computed standard errors of the monthly means by 1-degree square area for the eastward and northward components of the resultant surface wind stress. The standard errors of the means are defined by Equation (3). Each page contains values for 30 1-degree squares blocked in groups of 10. Within each group of 10, all 1-degree squares are defined by a common latitude. The first set of values corresponds to the 1-degree square immediately adjacent to the coast. The final tabulations refer to the 1-degree square farthest from the coast.

The standard error of the mean is tabulated for each month and square. The latitude and longitude of the center of the 1-degree square is listed at the left. The first two numbers below each month are the standard errors of the means for the eastward and northward components, respectively. The units are dyne cm^{-2}. The last value is the number of observations.

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
21 N 111 W	.04 .05 74	.03 .03 71	.03 .04 95	.03 .05 75	.03 .04 88	.04 .04 87	.06 .04 101	.04 .04 85	.08 .06 107	.06 .04 95	.08 .05 81	.02 .03 94
21 N 112 W	.03 .05 51	.02 .03 68	.02 .07 52	.03 .07 48	.04 .06 61	.03 .05 66	.08 .06 57	.11 .07 35	.08 .08 57	.04 .06 45	.04 .04 46	.04 .04 57
21 N 113 W	.04 .06 35	.11 .08 50	.04 .10 38	.04 .09 39	.05 .08 39	.04 .07 39	.05 .06 40	.15 .16 25	.08 .16 33	.04 .10 38	.08 .10 37	.05 .05 58
21 N 114 W	.04 .08 41	.10 .07 39	.04 .08 33	.07 .17 22	.05 .11 24	.08 .10 21	.08 .24 32	.15 .16 18	.35 .28 23	.07 .04 28	.03 .07 32	.05 .08 42
21 N 115 W	.16 .09 29	.09 .10 26	.08 .07 35	.08 .13 18	.05 .06 23	.06 .08 23	.03 .02 31	.05 .08 17	.08 .11 19	.07 .11 20	.03 .08 27	.04 .06 40
21 N 116 W	.15 .12 26	.04 .06 28	.07 .09 32	.09 .14 15	.10 .14 13	.07 .07 14	.08 .12 26	.14 .16 15	.20 .15 18	.08 .06 18	.04 .09 18	.03 .06 25
21 N 117 W	.06 .09 38	.03 .06 26	.07 .09 25	.11 .09 19	.05 .10 12	.05 .09 22	.16 .08 15	.13 .19 21	.14 .10 23	.09 .09 22	.02 .06 24	.04 .07 26
21 N 118 W	.09 .08 34	.10 .05 21	.06 .07 24	.14 .14 18	.08 .12 19	.08 .06 19	.12 .09 22	.19 .24 18	.11 .15 21	.03 .03 38	.05 .08 23	.05 .08 34
21 N 119 W	.09 .08 24	.07 .08 26	.06 .09 30	.11 .11 27	.04 .10 19	.09 .06 27	.16 .13 21	.11 .06 22	.08 .18 30	.04 .05 33	.04 .06 43	.07 .07 37
21 N 120 W	.09 .10 24	.05 .06 34	.06 .05 30	.05 .09 28	.06 .07 38	.06 .05 31	.12 .07 39	.05 .09 34	.07 .07 37	.09 .13 40	.05 .05 40	.08 .06 27
22 N 111 W	.02 .04 128	.03 .03 101	.02 .03 164	.04 .05 122	.02 .03 169	.03 .03 150	.03 .02 143	.03 .03 150	.07 .07 161	.03 .03 160	.02 .02 150	.03 .05 120
22 N 112 W	.02 .04 73	.02 .04 60	.03 .05 78	.06 .06 80	.03 .05 99	.03 .04 117	.02 .03 105	.15 .08 116	.04 .04 110	.04 .04 100	.02 .03 90	.03 .05 69
22 N 113 W	.03 .04 51	.04 .11 47	.03 .06 67	.05 .12 57	.03 .07 67	.03 .05 75	.03 .03 84	.04 .05 68	.09 .11 70	.03 .04 73	.03 .05 77	.06 .04 57
22 N 114 W	.03 .06 34	.04 .09 42	.04 .09 45	.02 .07 52	.05 .08 53	.03 .07 50	.04 .04 61	.09 .07 35	.11 .10 58	.03 .08 45	.04 .05 38	.03 .04 66
22 N 115 W	.07 .09 37	.10 .10 30	.06 .09 54	.04 .10 38	.05 .09 36	.03 .09 37	.05 .07 32	.19 .18 34	.09 .07 31	.07 .07 34	.04 .07 22	.07 .06 30
22 N 116 W	.06 .10 24	.05 .10 30	.04 .12 32	.11 .19 15	.05 .11 32	.08 .09 30	.03 .07 26	.32 .29 17	.26 .29 24	.08 .06 21	.04 .07 32	.07 .06 33
22 N 117 W	.05 .11 33	.05 .09 29	.08 .10 34	.05 .11 23	.07 .14 19	.08 .12 15	.07 .10 21	.13 .27 17	.12 .10 17	.05 .06 25	.06 .07 26	.05 .05 27
22 N 118 W	.06 .09 28	.11 .11 27	.04 .06 33	.10 .13 21	.08 .11 17	.06 .12 18	.15 .14 15	.05 .12 17	.21 .17 17	.05 .07 19	.06 .09 23	.05 .07 34
22 N 119 W	.07 .08 31	.07 .27 24	.08 .08 24	.07 .05 25	.10 .10 19	.04 .06 24	.06 .12 19	.12 .10 26	.19 .18 21	.10 .07 21	.12 .07 26	.05 .09 32
22 N 120 W	.07 .08 33	.08 .10 26	.07 .06 31	.09 .08 23	.04 .07 38	.17 .14 17	.08 .10 20	.14 .13 19	.11 .14 22	.07 .07 23	.06 .06 34	.07 .08 20
23 N 111 W	.01 .01 1059	.01 .01 1030	.01 .01 1125	.01 .01 1159	.01 .01 1241	.01 .01 1128	.01 0.00 1178	.02 .03 1152	.01 .01 1132	.01 .01 1199	.01 .01 1083	.03 .01 986
23 N 112 W	.02 .02 155	.02 .03 124	.02 .03 146	.03 .04 135	.03 .03 192	.02 .03 245	.02 .01 203	.04 .03 181	.03 .03 206	.02 .02 187	.02 .03 154	.03 .05 140
23 N 113 W	.03 .09 47	.03 .04 48	.06 .06 47	.03 .06 54	.03 .05 78	.05 .05 78	.02 .03 76	.04 .05 72	.04 .10 79	.03 .04 75	.02 .04 70	.06 .11 47
23 N 114 W	.04 .04 45	.02 .05 44	.04 .08 49	.05 .13 59	.03 .06 79	.03 .05 71	.02 .03 84	.04 .04 96	.05 .06 74	.04 .06 73	.03 .05 59	.06 .09 47
23 N 115 W	.11 .04 42	.03 .07 45	.04 .06 55	.03 .06 67	.03 .09 65	.02 .05 71	.03 .04 62	.05 .05 52	.04 .06 71	.04 .04 68	.05 .05 55	.05 .07 57
23 N 116 W	.04 .07 42	.07 .09 37	.04 .06 48	.05 .07 46	.03 .07 63	.05 .06 46	.03 .05 62	.07 .04 50	.05 .08 51	.04 .06 47	.05 .06 45	.06 .05 54
23 N 117 W	.09 .10 30	.04 .11 34	.06 .07 60	.05 .12 38	.06 .09 48	.04 .07 46	.04 .05 43	.16 .19 28	.09 .09 40	.05 .08 38	.09 .10 33	.05 .04 52
23 N 118 W	.05 .08 34	.10 .10 29	.03 .08 37	.05 .10 33	.06 .08 36	.06 .10 27	.05 .06 32	.16 .16 22	.11 .11 29	.06 .06 32	.06 .06 26	.04 .05 38
23 N 119 W	.06 .08 35	.05 .09 38	.03 .09 38	.06 .09 33	.05 .07 38	.06 .08 39	.06 .08 30	.07 .12 16	.10 .11 24	.07 .09 26	.17 .10 24	.10 .08 37
23 N 120 W	.10 .10 37	.05 .06 30	.06 .10 21	.11 .14 17	.04 .06 22	.05 .09 23	.08 .17 17	.08 .09 22	.07 .10 24	.08 .10 18	.14 .08 32	.06 .08 42

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
24 N 111 W	.01	.01	.01	.01	.02	.01	.01	.01	.03	.01	.01	.01
	.01	.01	.01	.01	.01	.01	.01	.01	.06	.01	.01	.01
	572	494	590	587	591	603	596	602	566	535	594	504
24 N 112 W	0.00	.01	.02	.01	.01	.01	.01	.01	.01	0.00	0.00	.01
	.01	.01	.01	.01	.01	.01	0.00	.01	.01	.01	.01	.01
	1226	1209	1375	1380	1458	1398	1453	1324	1382	1379	1336	1208
24 N 113 W	.02	.03	.03	.03	.02	.02	.02	.02	.03	.03	.02	.02
	.04	.04	.03	.05	.03	.03	.02	.02	.03	.03	.02	.03
	143	142	195	150	176	210	193	223	214	177	172	141
24 N 114 W	.07	.06	.05	.05	.04	.04	.03	.04	.05	.04	.05	.14
	.06	.09	.08	.07	.05	.05	.05	.06	.06	.05	.08	.18
	42	39	45	38	58	54	54	70	78	62	44	25
24 N 115 W	.07	.05	.05	.07	.04	.07	.03	.04	.05	.05	.03	.07
	.09	.08	.08	.15	.07	.10	.06	.05	.06	.05	.07	.10
	29	31	39	46	59	49	87	51	68	56	44	22
24 N 116 W	.05	.03	.08	.04	.04	.05	.02	.06	.04	.03	.02	.04
	.07	.06	.09	.08	.08	.06	.04	.05	.08	.05	.06	.10
	35	43	37	55	67	68	75	73	56	59	56	39
24 N 117 W	.05	.06	.04	.06	.04	.03	.03	.04	.04	.03	.04	.04
	.07	.15	.09	.18	.08	.07	.06	.05	.06	.05	.05	.05
	43	29	33	44	62	71	71	62	60	56	51	57
24 N 118 W	.05	.06	.04	.05	.05	.03	.02	.09	.05	.04	.04	.07
	.06	.08	.06	.09	.08	.06	.06	.06	.08	.05	.06	.06
	35	47	49	40	52	52	47	44	50	57	48	39
24 N 119 W	.03	.11	.08	.05	.04	.03	.06	.13	.05	.04	.08	.04
	.05	.13	.07	.10	.07	.09	.08	.08	.09	.07	.08	.04
	40	41	56	44	57	39	53	38	36	40	36	50
24 N 120 W	.07	.04	.03	.05	.05	.05	.08	.15	.08	.07	.05	.05
	.08	.07	.08	.08	.06	.09	.05	.10	.11	.05	.06	.06
	47	55	57	45	41	30	38	29	35	38	46	48
25 N 113 W	0.00	.01	.01	.01	.01	.01	.01	0.00	.01	0.00	0.00	.01
	.01	.01	.01	.01	.01	.01	0.00	.01	.01	.01	.01	.01
	1297	1257	1441	1409	1509	1467	1508	1431	1431	1426	1408	1269
25 N 114 W	.02	.02	.04	.03	.03	.03	.04	.02	.03	.13	.03	.03
	.04	.04	.05	.05	.04	.03	.04	.02	.04	.06	.04	.03
	147	128	139	150	176	206	177	225	200	185	149	125
25 N 115 W	.56	.04	.05	.03	.03	.05	.03	.04	.03	.02	.05	.08
	.65	.09	.08	.08	.07	.08	.04	.04	.06	.04	.05	.09
	31	32	42	59	86	66	81	73	67	66	46	30
25 N 116 W	.10	.08	.12	.05	.08	.06	.03	.02	.14	.04	.05	.10
	.17	.06	.13	.12	.08	.09	.05	.03	.08	.11	.06	.16
	15	22	27	23	35	31	46	53	44	25	37	14
25 N 117 W	.04	.11	.10	.04	.04	.05	.03	.06	.06	.05	.05	.11
	.07	.10	.12	.09	.06	.06	.05	.06	.08	.07	.08	.16
	23	27	30	35	52	40	51	59	38	45	34	22
25 N 118 W	.06	.04	.06	.05	.04	.04	.02	.05	.06	.02	.05	.03
	.06	.10	.10	.20	.08	.06	.05	.07	.10	.05	.08	.08
	33	29	34	41	61	58	67	57	48	61	42	50
25 N 119 W	.06	.06	.05	.05	.05	.04	.03	.03	.04	.03	.05	.05
	.08	.10	.07	.14	.08	.07	.07	.05	.09	.05	.11	.06
	52	34	50	42	54	70	58	59	56	58	49	48
25 N 120 W	.07	.07	.04	.04	.04	.03	.02	.04	.04	.04	.04	.07
	.09	.12	.06	.08	.07	.05	.04	.06	.07	.06	.09	.08
	37	36	49	52	61	44	55	51	41	45	54	36
25 N 121 W	.07	.05	.03	.05	.04	.04	.03	.08	.08	.05	.09	.07
	.06	.10	.06	.07	.06	.06	.06	.08	.08	.05	.15	.07
	46	42	53	38	49	41	55	46	41	60	33	37
25 N 122 W	.05	.07	.04	.05	.02	.04	.04	.06	.06	.05	.10	.09
	.08	.08	.06	.08	.05	.05	.06	.06	.09	.06	.06	.06
	55	52	56	59	68	36	44	45	48	54	49	56
26 N 113 W	.01	.01	.02	.02	.02	.01	.01	.01	.02	.01	.01	.02
	.02	.02	.02	.02	.02	.02	.06	.01	.02	.02	.02	.02
	372	399	424	397	444	452	398	408	428	427	439	389
26 N 114 W	.01	.01	.01	.01	.01	.01	.01	.01	.01	.02	.01	.01
	.01	.01	.01	.01	.01	.01	.01	.01	.01	.02	.01	.01
	1199	1201	1438	1327	1367	1334	1360	1346	1331	1333	1253	1165
26 N 115 W	.04	.03	.04	.03	.04	.02	.02	.02	.03	.03	.02	.03
	.04	.04	.05	.05	.04	.04	.03	.03	.05	.04	.04	.05
	120	115	125	117	135	158	148	150	147	129	129	96
26 N 116 W	.08	.07	.08	.06	.04	.04	.03	.03	.04	.03	.05	.15
	.09	.14	.10	.10	.07	.07	.04	.05	.07	.05	.08	.80
	30	24	34	45	65	68	68	59	66	55	60	30
26 N 117 W	.07	.12	.24	.04	.03	.03	.04	.05	.04	.03	.04	.20
	.16	.18	.28	.09	.07	.09	.05	.08	.09	.06	.05	.19
	16	15	16	33	30	37	59	48	42	35	30	16
26 N 118 W	.04	.06	.12	.04	.04	.04	.04	.05	.04	.04	.05	.10
	.09	.09	.12	.15	.08	.07	.05	.06	.07	.07	.10	.14
	32	24	32	26	35	34	35	43	52	39	25	13
26 N 119 W	.05	.10	.06	.05	.04	.04	.03	.02	.06	.05	.04	.04
	.09	.11	.09	.14	.08	.08	.06	.08	.10	.07	.07	.09
	33	29	26	33	41	36	43	38	24	30	37	27
26 N 120 W	.10	.10	.09	.11	.03	.02	.05	.03	.06	.03	.06	.05
	.07	.15	.15	.09	.08	.05	.08	.06	.09	.06	.06	.09
	30	24	34	38	57	59	50	45	48	57	43	38
26 N 121 W	.05	.10	.04	.04	.04	.03	.08	.03	.04	.04	.05	.07
	.07	.12	.10	.09	.09	.06	.08	.05	.09	.05	.14	.08
	59	26	40	54	55	69	43	66	47	51	42	46
26 N 122 W	.05	.04	.06	.03	.03	.02	.03	.03	.03	.03	.03	.08
	.06	.06	.06	.09	.07	.04	.05	.05	.06	.04	.05	.07
	37	52	61	54	55	57	60	57	60	63	70	50

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
27 N	.02	.02	.02	.02	.02	.02	.01	.01	.02	.01	.02	.02
114 W	.02	.02	.02	.02	.02	.02	.01	.01	.02	.01	.02	.02
	468	458	542	517	548	488	527	452	549	524	511	521
27 N	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
115 W	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.02
	1113	1085	1245	1204	1250	1194	1209	1188	1169	1183	1122	973
27 N	.06	.04	.02	.03	.04	.04	.02	.02	.03	.03	.03	.04
116 W	.07	.06	.10	.04	.05	.05	.04	.03	.06	.06	.05	.07
	76	102	88	108	101	110	99	120	130	84	86	62
27 N	.08	.05	.08	.05	.05	.03	.03	.03	.03	.43	.06	.06
117 W	.12	.07	.10	.11	.08	.06	.06	.06	.05	.73	.07	.10
	29	34	43	48	51	64	71	71	76	55	51	25
27 N	.06	.07	.10	.05	.04	.03	.02	.03	.04	.03	.05	.24
118 W	.10	.16	.14	.11	.08	.06	.05	.04	.08	.04	.09	.10
	28	20	23	32	36	43	70	53	49	31	37	19
27 N	.03	.10	.11	.05	.04	.04	.03	.04	.04	.03	.04	.04
119 W	.09	.32	.08	.09	.10	.10	.10	.05	.07	.06	.05	.22
	19	12	16	34	32	32	29	32	37	37	26	20
27 N	.07	.11	.08	.05	.03	.03	.04	.04	.08	.04	.09	.06
120 W	.11	.27	.11	.11	.14	.08	.07	.07	.09	.09	.14	.08
	34	19	23	20	30	33	29	38	36	26	17	15
27 N	.13	.06	.11	.05	.04	.05	.04	.03	.06	.04	.07	.08
121 W	.09	.05	.12	.12	.08	.10	.12	.05	.13	.07	.07	.14
	40	25	29	42	46	18	31	49	24	49	33	17
27 N	.07	.09	.05	.03	.05	.05	.05	.04	.06	.02	.07	.07
122 W	.06	.12	.11	.10	.08	.06	.09	.08	.09	.05	.08	.05
	36	33	51	53	58	64	54	62	48	75	53	62
27 N	.04	.08	.06	.03	.02	.03	.05	.03	.03	.02	.06	.06
123 W	.07	.09	.09	.07	.05	.06	.08	.05	.04	.04	.08	.09
	69	52	63	75	93	90	60	80	91	105	77	51
28 N	.03	.02	.01	.02	.01	.01	.01	.01	.01	.01	.01	.02
115 W	.06	.02	.02	.03	.02	.01	.01	.01	.02	.01	.02	.02
	588	517	742	720	723	668	632	685	709	695	676	624
28 N	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.02
116 W	.02	.02	.02	.02	.01	.01	.01	.01	.01	.01	.01	.02
	810	747	865	843	874	903	831	840	835	875	821	735
28 N	.06	.05	.05	.03	.04	.03	.04	.03	.04	.04	.04	.09
117 W	.05	.07	.05	.05	.06	.04	.05	.07	.05	.05	.08	.12
	75	72	65	69	59	69	53	66	75	71	55	56
28 N	.05	.07	.05	.07	.05	.03	.02	.04	.04	.02	.05	.05
118 W	.06	.11	.09	.15	.06	.07	.06	.04	.07	.06	.10	.14
	34	24	25	30	41	47	56	63	54	43	33	22
28 N	.06	.04	.05	.05	.04	.04	.03	.03	.04	.03	.06	.13
119 W	.06	.11	.08	.09	.05	.07	.07	.07	.11	.06	.10	.14
	38	30	33	43	53	72	67	55	39	39	33	19
28 N	.20	.29	.08	.05	.06	.03	.06	.04	.03	.05	.05	.10
120 W	.15	.36	.09	.11	.11	.08	.06	.07	.06	.08	.12	.20
	17	18	36	43	33	39	36	41	45	22	31	20
28 N	.06	.08	.08	.05	.04	.05	.05	.02	.04	.04	.03	.06
121 W	.09	.25	.11	.10	.09	.10	.09	.05	.09	.07	.08	.10
	35	14	28	41	31	41	29	48	32	39	31	23
28 N	.06	.04	.07	.05	.05	.05	.03	.05	.03	.03	.08	.05
122 W	.11	.10	.12	.10	.13	.08	.08	.08	.05	.08	.16	.11
	56	34	45	32	44	44	55	58	43	54	27	35
28 N	.10	.08	.06	.03	.05	.05	.03	.07	.04	.03	.07	.06
123 W	.12	.10	.12	.10	.06	.11	.10	.07	.05	.04	.09	.06
	47	50	44	68	70	37	41	65	65	80	75	58
28 N	.06	.05	.05	.05	.03	.06	.06	.08	.09	.02	.06	.06
124 W	.08	.07	.12	.09	.07	.06	.09	.07	.08	.04	.07	.09
	48	46	43	44	65	54	46	47	38	88	67	51
29 N	.07	.07	.11	.07	.09	.05	.07	.07	.05	.05	.12	.08
115 W	.09	.08	.09	.09	.10	.06	.07	.04	.07	.05	.07	.09
	62	88	90	80	71	66	61	63	59	58	73	67
29 N	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
116 W	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
	1130	1149	1209	1155	1246	1080	1081	1115	1109	1112	1051	983
29 N	.03	.02	.02	.02	.02	.02	.02	.01	.02	.02	.02	.03
117 W	.03	.03	.03	.03	.03	.02	.02	.02	.02	.02	.03	.03
	252	249	336	308	250	294	267	280	273	265	261	229
29 N	.03	.08	.07	.07	.05	.04	.05	.03	.08	.04	.05	.06
118 W	.06	.10	.08	.07	.07	.07	.06	.05	.06	.05	.05	.09
	108	58	71	65	59	64	49	56	54	55	56	37
29 N	.07	.07	.10	.05	.05	.04	.03	.05	.04	.02	.10	.05
119 W	.09	.09	.22	.08	.10	.09	.07	.10	.09	.05	.09	.07
	27	21	34	35	43	45	43	33	42	54	33	35
29 N	.06	.07	.10	.05	.04	.04	.05	.03	.04	.06	.06	.06
120 W	.11	.09	.15	.09	.07	.08	.07	.05	.08	.09	.09	.11
	29	28	25	55	48	44	52	68	55	36	27	36
29 N	.05	.11	.09	.05	.05	.03	.04	.03	.07	.04	.46	.08
121 W	.08	.12	.12	.08	.08	.07	.08	.07	.07	.08	1.27	.09
	59	29	42	50	51	69	59	54	45	44	42	34
29 N	.05	.09	.07	.04	.05	.03	.04	.03	.05	.03	.07	.08
122 W	.10	.13	.13	.10	.06	.06	.09	.06	.06	.06	.07	.08
	73	48	51	56	81	84	52	86	44	82	62	39
29 N	.08	.05	.09	.05	.04	.03	.03	.16	.02	.03	.07	.06
123 W	.12	.13	.11	.12	.07	.08	.06	.07	.05	.06	.09	.09
	63	39	39	45	65	61	65	61	73	68	54	58
29 N	.06	.07	.07	.05	.03	.04	.04	.02	.06	.04	.07	.08
124 W	.11	.07	.14	.08	.07	.07	.10	.05	.05	.06	.08	.11
	51	50	36	50	76	54	54	57	53	80	89	31

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
30 N 116 W	.02 .02 571	.02 .02 506	.02 .03 637	.01 .02 581	.01 .02 624	.01 .02 593	.01 .01 547	.01 .01 537	.01 .02 553	.01 .02 557	.01 .02 545	.01 .02 481
30 N 117 W	.01 .02 604	.01 .02 630	.01 .02 698	.01 .02 668	.05 .04 658	.01 .01 654	.01 .01 666	.01 .01 693	.01 .02 651	.01 .01 672	.03 .04 645	.02 .02 591
30 N 118 W	.04 .05 194	.02 .03 209	.03 .04 187	.04 .04 201	.03 .04 193	.03 .04 190	.02 .03 195	.02 .02 188	.02 .03 180	.02 .02 203	.03 .03 182	.04 .05 165
30 N 119 W	.07 .08 76	.06 .09 65	.07 .08 60	.04 .05 65	.10 .10 38	.04 .06 73	.02 .03 139	.03 .06 52	.05 .08 60	.06 .05 91	.06 .10 48	.08 .10 42
30 N 120 W	.05 .09 63	.05 .08 113	.08 .10 58	.05 .07 99	.03 .05 86	.05 .06 91	.04 .06 67	.05 .06 70	.04 .05 56	.04 .04 95	.07 .07 37	.06 .10 52
30 N 121 W	.07 .08 71	.06 .07 81	.07 .11 58	.04 .08 107	.03 .07 91	.04 .05 86	.03 .05 84	.03 .05 102	.04 .06 70	.03 .06 89	.04 .08 35	.10 .11 53
30 N 122 W	.05 .07 92	.12 .16 60	.09 .12 47	.08 .11 51	.04 .08 100	.03 .08 104	.03 .06 77	.04 .06 88	.04 .07 73	.05 .06 74	.05 .08 51	.05 .09 49
30 N 123 W	.05 .08 78	.13 .13 50	.12 .15 48	.07 .14 54	.04 .06 87	.03 .07 80	.03 .06 72	.03 .12 73	.06 .09 69	.03 .09 82	.04 .10 69	.03 .05 96
30 N 124 W	.11 .11 66	.09 .11 80	.04 .07 55	.03 .07 75	.04 .07 110	.02 .05 108	.04 .08 60	.05 .07 83	.03 .07 66	.03 .07 113	.04 .09 87	.05 .09 63
30 N 125 W	.08 .12 78	.10 .15 66	.06 .10 57	.05 .10 65	.07 .08 55	.04 .08 78	.04 .08 64	.04 .08 78	.04 .06 70	.03 .07 86	.06 .09 72	.06 .08 65
31 N 117 W	.01 .01 776	.01 .02 793	.01 .01 922	.01 .01 880	.01 .01 916	.01 .01 866	.01 .01 826	.01 .01 837	.01 .01 861	.01 .01 821	.01 .02 793	.01 .02 706
31 N 118 W	.02 .03 394	.03 .03 402	.02 .03 446	.02 .02 442	.02 .03 441	.02 .02 384	.01 .02 360	.01 .01 443	.02 .02 499	.02 .02 441	.02 .02 459	.03 .03 372
31 N 119 W	.02 .03 294	.02 .04 294	.04 .06 236	.04 .04 286	.03 .03 253	.02 .03 296	.02 .03 255	.02 .03 214	.02 .03 267	.02 .02 345	.04 .04 222	.04 .05 154
31 N 120 W	.05 .07 159	.04 .06 143	.05 .07 131	.05 .06 149	.04 .06 144	.03 .05 124	.03 .05 158	.03 .04 126	.04 .06 98	.03 .03 212	.04 .07 122	.03 .06 84
31 N 121 W	.05 .08 153	.04 .08 145	.05 .10 101	.03 .06 131	.06 .06 119	.05 .07 105	.03 .04 132	.04 .05 95	.04 .08 78	.04 .05 131	.04 .06 101	.06 .08 78
31 N 122 W	.04 .06 115	.05 .10 98	.05 .10 97	.08 .11 70	.06 .07 104	.03 .07 104	.03 .05 106	.04 .06 87	.04 .09 79	.03 .08 127	.05 .10 107	.05 .08 87
31 N 123 W	.03 .06 171	.06 .10 110	.06 .08 84	.04 .10 91	.04 .06 109	.03 .07 123	.02 .05 170	.03 .05 142	.03 .06 133	.03 .07 153	.04 .06 111	.05 .10 79
31 N 124 W	.07 .09 112	.07 .12 86	.06 .10 105	.04 .07 173	.02 .04 207	.03 .06 169	.02 .05 166	.02 .06 102	.03 .06 133	.03 .05 146	.05 .08 119	.06 .10 107
31 N 125 W	.06 .08 134	.05 .09 121	.04 .07 139	.05 .08 144	.03 .06 126	.03 .06 150	.02 .04 160	.03 .07 125	.03 .06 124	.03 .08 166	.05 .09 122	.05 .11 92
31 N 126 W	.05 .08 157	.06 .10 137	.06 .07 152	.04 .07 145	.03 .05 149	.03 .05 155	.03 .06 158	.02 .05 145	.02 .04 144	.03 .06 180	.05 .06 148	.05 .09 131
32 N 117 W	.01 .01 1046	.01 .01 912	.01 .01 1055	.01 .01 967	.01 .01 1095	0.00 0.00 1059	0.00 0.00 931	0.00 0.00 1097	.01 .01 1041	.01 .01 1062	.01 .01 887	.01 .01 714
32 N 118 W	.01 .01 2163	.01 .01 1933	.01 .01 2268	.01 .01 2283	.01 0.00 2375	0.00 0.00 2221	.01 0.00 1934	0.00 0.00 2512	.01 0.00 2363	.01 .01 2284	.01 .01 1882	.01 .01 1133
32 N 119 W	.01 .02 1108	.02 .02 981	.02 .02 1244	.01 .02 1106	.01 .01 1140	.01 .01 1008	.01 .01 1054	.02 .01 1128	.01 .01 1220	.01 .01 1399	.02 .02 1017	.02 .02 768
32 N 120 W	.02 .03 451	.03 .05 350	.03 .03 491	.03 .04 479	.03 .03 465	.03 .04 354	.02 .02 500	.02 .02 433	.02 .02 573	.02 .03 492	.02 .03 419	.04 .05 262
32 N 121 W	.03 .06 241	.04 .06 252	.04 .07 235	.04 .05 249	.03 .05 254	.04 .05 196	.02 .04 272	.03 .04 225	.03 .04 245	.02 .04 293	.05 .06 233	.05 .07 189
32 N 122 W	.04 .07 198	.05 .08 214	.04 .08 212	.06 .08 214	.04 .06 188	.03 .06 190	.03 .05 229	.04 .06 171	.03 .05 191	.03 .04 302	.03 .05 208	.05 .08 176
32 N 123 W	.03 .06 287	.05 .08 197	.04 .07 218	.05 .08 198	.04 .07 190	.03 .07 172	.02 .04 203	.03 .05 188	.03 .05 181	.03 .06 253	.03 .06 232	.04 .08 184
32 N 124 W	.01 .04 771	.02 .04 531	.02 .03 630	.03 .05 432	.01 .04 569	.01 .03 551	.01 .02 662	.01 .02 711	.01 .02 662	.01 .04 828	.02 .03 623	.01 .03 637
32 N 125 W	.03 .05 302	.03 .06 273	.05 .06 289	.04 .05 267	.04 .05 273	.02 .05 263	.02 .05 268	.02 .04 284	.02 .04 237	.02 .05 353	.02 .04 323	.03 .06 363
32 N 126 W	.03 .05 289	.05 .07 252	.03 .05 307	.03 .05 300	.03 .05 278	.02 .04 257	.02 .05 267	.02 .04 280	.01 .04 247	.02 .05 320	.03 .04 352	.03 .06 311

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
33 N 118 W	0.00 0.00 3538	.01 .01 3329	.01 0.00 3831	.01 0.00 3776	0.00 0.00 3805	0.00 0.00 3305	0.00 0.00 3107	0.00 0.00 3712	0.00 0.00 3483	0.00 0.00 3798	0.00 0.00 3536	.01 .01 2251
33 N 119 W	.01 .01 1351	.02 .02 1121	.02 .01 1557	.02 .01 1412	.02 .01 1492	.01 .01 1320	.01 .01 1079	.01 0.00 1595	.01 .01 1476	.01 .01 1686	.01 .01 1461	.02 .01 1023
33 N 120 W	.02 .02 966	.03 .04 510	.02 .02 930	.03 .02 935	.02 .02 1064	.02 .02 1124	.02 .02 823	.01 .02 967	.01 .02 1000	.01 .02 975	.02 .02 934	.03 .03 699
33 N 121 W	.02 .04 473	.03 .06 289	.04 .06 392	.04 .05 333	.05 .06 410	.03 .04 415	.03 .05 303	.02 .03 341	.03 .04 384	.03 .04 310	.03 .05 341	.03 .05 293
33 N 122 W	.03 .06 345	.04 .07 305	.04 .06 372	.04 .05 350	.03 .04 332	.04 .06 276	.04 .05 306	.02 .04 269	.02 .04 298	.03 .06 297	.03 .05 347	.03 .05 332
33 N 123 W	.03 .06 363	.03 .06 313	.04 .06 336	.02 .04 575	.02 .05 462	.03 .05 329	.02 .03 411	.02 .04 286	.02 .04 308	.02 .04 310	.03 .05 345	.03 .05 362
33 N 124 W	.02 .05 400	.03 .06 286	.03 .05 395	.04 .06 313	.02 .05 389	.03 .05 319	.02 .05 314	.01 .03 378	.02 .04 287	.02 .05 406	.03 .05 377	.03 .05 377
33 N 125 W	.03 .05 356	.03 .06 318	.03 .05 330	.03 .05 272	.02 .05 324	.03 .05 285	.02 .04 273	.01 .04 306	.02 .05 238	.02 .05 329	.03 .04 339	.03 .06 356
33 N 126 W	.06 .07 244	.04 .08 187	.04 .08 217	.04 .08 185	.02 .05 217	.03 .06 164	.02 .06 204	.03 .06 187	.02 .05 182	.02 .06 216	.03 .06 221	.03 .06 256
33 N 127 W	.05 .08 196	.05 .09 178	.04 .07 199	.07 .08 154	.03 .07 164	.04 .06 152	.03 .06 178	.03 .06 137	.03 .07 143	.03 .06 182	.05 .06 183	.06 .11 199
34 N 119 W	.01 .01 1505	.01 .01 1537	.01 0.00 1774	.01 0.00 1990	.01 .01 1924	0.00 0.00 1615	0.00 0.00 1623	0.00 0.00 1420	.01 0.00 1448	.01 0.00 1472	.01 .01 1261	.02 .01 995
34 N 120 W	.02 .02 599	.03 .03 588	.03 .02 743	.03 .03 705	.04 .03 643	.02 .02 721	.02 .02 775	.03 .02 650	.02 .02 656	.02 .02 640	.02 .02 652	.02 .02 769
34 N 121 W	.02 .03 576	.03 .04 506	.03 .04 594	.03 .04 535	.03 .04 543	.02 .03 676	.02 .03 603	.02 .02 650	.02 .03 577	.02 .03 567	.02 .03 558	.03 .04 495
34 N 122 W	.03 .05 276	.04 .07 261	.04 .07 274	.04 .07 239	.04 .06 258	.07 .09 265	.03 .04 284	.03 .04 232	.03 .05 246	.04 .07 228	.04 .08 272	.03 .05 256
34 N 123 W	.04 .07 230	.05 .08 228	.03 .08 258	.04 .07 185	.05 .08 189	.05 .08 190	.04 .06 197	.04 .06 156	.04 .05 172	.03 .07 263	.04 .06 207	.03 .07 212
34 N 124 W	.03 .05 265	.05 .07 204	.04 .07 229	.05 .07 218	.06 .08 147	.04 .07 166	.04 .08 152	.04 .06 146	.03 .13 188	.03 .06 273	.04 .07 206	.04 .07 241
34 N 125 W	.04 .06 229	.05 .08 199	.04 .07 240	.05 .07 204	.05 .08 152	.04 .07 143	.04 .07 149	.07 .07 137	.03 .06 175	.02 .07 234	.03 .05 217	.06 .09 234
34 N 126 W	.07 .08 206	.05 .09 200	.05 .07 204	.06 .09 196	.05 .09 149	.04 .08 132	.03 .07 141	.04 .07 101	.04 .06 142	.03 .06 189	.05 .08 184	.04 .07 232
34 N 127 W	.05 .08 208	.06 .07 182	.06 .07 212	.05 .08 185	.05 .08 138	.04 .07 134	.04 .08 122	.03 .08 96	.03 .08 145	.03 .06 164	.05 .08 187	.05 .06 218
34 N 128 W	.05 .08 230	.06 .08 184	.06 .07 224	.06 .09 182	.04 .07 179	.04 .07 148	.03 .06 127	.04 .06 129	.03 .07 130	.05 .06 169	.05 .08 186	.05 .07 215
35 N 121 W	.02 .03 525	.03 .04 477	.03 .04 613	.03 .04 572	.03 .03 586	.03 .04 651	.02 .02 631	.02 .03 564	.02 .02 536	.02 .03 658	.02 .03 559	.03 .04 447
35 N 122 W	.03 .05 296	.03 .05 310	.04 .05 376	.03 .05 388	.03 .04 432	.02 .04 480	.03 .04 441	.02 .03 445	.02 .03 418	.03 .04 422	.02 .04 423	.02 .05 274
35 N 123 W	.04 .07 243	.04 .08 218	.04 .07 224	.03 .05 284	.03 .06 276	.04 .06 296	.03 .04 293	.02 .06 325	.02 .04 306	.02 .04 262	.03 .06 283	.04 .08 211
35 N 124 W	.04 .08 222	.05 .09 202	.04 .08 186	.05 .08 189	.03 .06 243	.04 .06 229	.03 .06 225	.03 .05 243	.02 .04 204	.02 .05 279	.03 .06 237	.05 .09 202
35 N 125 W	.07 .12 207	.04 .07 178	.05 .08 171	.05 .09 165	.05 .09 161	.04 .07 200	.03 .06 177	.03 .06 174	.04 .07 174	.03 .07 187	.03 .06 207	.06 .10 169
35 N 126 W	.06 .12 189	.07 .10 147	.05 .12 157	.04 .10 183	.06 .08 141	.04 .08 134	.04 .08 138	.04 .06 147	.04 .07 139	.04 .08 174	.04 .08 179	.06 .08 184
35 N 127 W	.05 .09 193	.05 .08 181	.06 .08 198	.05 .08 171	.04 .09 153	.05 .07 154	.04 .08 129	.03 .06 150	.03 .07 111	.05 .08 206	.05 .09 191	.05 .09 201
35 N 128 W	.04 .06 366	.05 .07 317	.04 .06 373	.05 .05 259	.03 .05 270	.02 .06 243	.02 .05 313	.02 .04 316	.03 .06 273	.02 .05 356	.03 .05 370	.05 .06 368
35 N 129 W	.04 .06 400	.05 .06 394	.03 .05 479	.04 .05 379	.02 .04 352	.02 .04 337	.02 .04 312	.02 .03 326	.02 .05 324	.03 .05 404	.03 .05 373	.04 .05 411
35 N 130 W	.04 .05 568	.04 .05 523	.03 .05 577	.04 .04 487	.02 .04 492	.02 .03 442	.02 .04 464	.01 .03 446	.02 .04 476	.02 .04 592	.03 .04 554	.03 .05 562

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
36 N 122 W	.02 .04 552	.03 .05 465	.03 .04 592	.02 .04 621	.03 .04 631	.02 .03 759	.02 .03 767	.02 .03 561	.02 .03 604	.02 .04 553	.02 .03 561	.03 .04 411
36 N 123 W	.03 .06 286	.04 .06 342	.03 .06 298	.03 .07 364	.02 .04 468	.02 .04 591	.02 .04 577	.02 .03 525	.02 .03 478	.02 .05 418	.03 .05 380	.04 .09 247
36 N 124 W	.05 .08 240	.03 .08 228	.04 .06 215	.03 .07 279	.03 .05 360	.03 .05 351	.03 .05 339	.02 .04 360	.03 .05 286	.02 .06 269	.03 .06 257	.04 .06 246
36 N 125 W	.05 .08 296	.04 .09 206	.04 .07 225	.04 .08 271	.04 .06 281	.03 .06 298	.03 .06 297	.03 .05 291	.02 .07 258	.03 .07 250	.03 .06 270	.04 .07 255
36 N 126 W	.04 .08 446	.03 .06 414	.03 .06 449	.03 .06 368	.03 .05 371	.03 .06 357	.02 .05 358	.02 .04 382	.02 .06 352	.03 .06 398	.02 .05 530	.04 .07 397
36 N 127 W	.02 .04 899	.03 .05 748	.03 .04 694	.02 .04 624	.02 .04 651	.02 .04 655	.02 .04 584	.01 .03 714	.02 .04 646	.02 .04 699	.02 .04 660	.02 .05 734
36 N 128 W	.02 .04 1060	.03 .04 975	.02 .03 963	.02 .03 855	.01 .03 769	.01 .03 868	.01 .03 861	.01 .02 952	.01 .04 929	.02 .03 913	.02 .03 1168	.02 .03 997
36 N 129 W	.04 .05 519	.04 .05 511	.03 .04 682	.03 .04 616	.02 .04 566	.02 .04 581	.01 .03 552	.01 .03 585	.01 .03 637	.03 .04 612	.03 .04 598	.04 .06 620
36 N 130 W	.06 .08 303	.06 .06 315	.04 .06 382	.05 .06 331	.03 .06 274	.02 .05 298	.02 .05 249	.02 .04 259	.04 .05 299	.03 .04 373	.04 .05 404	.06 .07 322
36 N 131 W	.08 .09 235	.08 .08 266	.06 .08 272	.05 .07 238	.04 .06 212	.04 .05 209	.03 .05 138	.03 .05 185	.04 .06 191	.04 .06 250	.06 .08 251	.07 .08 234
37 N 122 W	.03 .05 412	.03 .05 337	.03 .04 343	.03 .04 378	.03 .04 432	.03 .04 391	.01 .02 581	.02 .03 354	.02 .03 400	.02 .03 433	.02 .04 376	.03 .05 325
37 N 123 W	.03 .05 588	.03 .06 591	.04 .05 688	.03 .05 672	.03 .04 738	.02 .03 998	.02 .02 881	.01 .03 836	.01 .02 882	.02 .04 797	.03 .04 687	.04 .06 637
37 N 124 W	.04 .07 578	.04 .06 572	.03 .05 605	.03 .05 514	.04 .06 504	.03 .05 570	.03 .04 523	.02 .04 537	.02 .04 533	.03 .05 602	.02 .04 645	.03 .05 534
37 N 125 W	.02 .05 731	.03 .05 586	.02 .04 789	.02 .05 719	.02 .04 748	.02 .04 696	.02 .03 706	.02 .03 681	.02 .04 664	.02 .04 755	.02 .04 883	.02 .05 688
37 N 126 W	.03 .05 633	.02 .05 545	.02 .05 696	.02 .05 703	.02 .05 685	.02 .04 720	.02 .04 684	.01 .03 603	.02 .04 602	.01 .04 651	.02 .04 722	.02 .05 617
37 N 127 W	.04 .06 435	.04 .08 391	.03 .06 424	.03 .05 473	.02 .05 532	.02 .06 447	.02 .05 438	.02 .05 406	.02 .05 453	.02 .05 528	.04 .05 489	.03 .07 430
37 N 128 W	.06 .08 313	.06 .09 299	.04 .07 352	.03 .05 343	.02 .05 369	.02 .05 361	.03 .06 286	.02 .06 274	.02 .06 405	.02 .05 410	.04 .06 357	.06 .07 337
37 N 129 W	.06 .08 263	.06 .08 236	.06 .09 279	.04 .06 322	.04 .06 306	.03 .06 331	.02 .06 253	.02 .05 283	.02 .05 333	.03 .05 387	.04 .06 351	.06 .09 271
37 N 130 W	.06 .09 233	.06 .08 230	.05 .08 243	.04 .07 312	.04 .05 281	.02 .05 306	.02 .05 271	.03 .05 261	.03 .05 345	.03 .05 338	.05 .06 298	.06 .10 257
37 N 131 W	.07 .09 223	.07 .10 201	.08 .10 209	.05 .05 265	.04 .05 229	.04 .06 239	.02 .05 234	.02 .04 242	.03 .05 262	.04 .05 291	.05 .07 266	.07 .08 254
38 N 123 W	.02 .03 956	.02 .03 919	.03 .03 937	.03 .03 1139	.02 .03 1121	.03 .03 1034	.01 .02 1132	.02 .02 931	.01 .02 1025	.01 .03 986	.02 .03 827	.03 .03 791
38 N 124 W	.04 .09 319	.04 .08 332	.04 .06 351	.03 .06 464	.04 .06 459	.03 .05 568	.03 .05 560	.02 .04 563	.02 .04 533	.03 .04 423	.03 .05 530	.04 .07 453
38 N 125 W	.05 .09 208	.05 .10 222	.05 .12 216	.04 .08 296	.04 .09 274	.04 .07 315	.03 .06 338	.03 .05 370	.03 .07 327	.03 .07 287	.03 .06 289	.05 .09 222
38 N 126 W	.08 .14 162	.04 .11 229	.05 .09 191	.04 .10 215	.03 .08 259	.03 .08 248	.04 .06 292	.03 .05 340	.03 .06 300	.03 .09 272	.06 .08 239	.07 .12 211
38 N 127 W	.07 .17 175	.07 .11 176	.05 .08 233	.04 .08 243	.02 .07 318	.03 .06 338	.03 .06 384	.03 .06 349	.03 .06 318	.03 .08 285	.04 .06 266	.08 .11 214
38 N 128 W	.06 .13 [illegible]	.09 .12 193	.04 .07 261	.04 .07 277	.03 .05 383	.02 .06 381	.02 .05 449	.02 .04 435	.02 .05 416	.04 .07 300	.05 .07 282	.07 .09 239
38 N 129 W	.08 .13 177	.06 [illegible] 206	.06 .09 214	.05 .05 247	.03 .05 307	.02 .09 330	.02 .05 355	.02 .05 337	.03 .05 320	.03 .07 249	.05 .06 253	.08 .09 217
38 N 130 W	.09 .15 140	.12 .11 172	.07 .10 170	.06 .08 180	.03 .06 247	.03 .05 258	.03 .05 273	.02 .04 281	.03 .05 272	.05 .08 192	.08 .09 206	.10 .10 196
38 N 131 W	.09 .13 160	.08 .12 146	.07 .12 151	.07 .09 151	.03 .05 248	.04 .08 201	.03 .05 232	.02 .04 291	.04 .06 221	.06 .08 198	.07 .08 174	.08 .12 190
38 N 132 W	.11 .17 126	.13 .12 139	.08 .08 166	.07 .09 145	.05 .07 189	.04 .06 181	.03 .05 208	.06 .05 225	.04 .04 238	.08 .08 193	.07 .08 178	.11 .12 157

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
39 N 124 W	.04 .08 337	.04 .07 393	.03 .06 392	.04 .06 437	.05 .08 423	.04 .06 496	.03 .07 465	.03 .05 415	.03 .05 420	.02 .05 406	.03 .05 422	.09 .12 344
39 N 125 W	.10 .12 181	.06 .10 171	.08 .15 162	.05 .10 202	.05 .10 229	.05 .10 273	.04 .08 311	.04 .08 267	.04 .09 242	.04 .08 218	.05 .12 157	.05 .12 158
39 N 126 W	.07 .17 172	.09 .11 160	.07 .11 165	.04 .09 231	.04 .09 232	.03 .07 301	.03 .06 331	.03 .07 318	.03 .07 269	.07 .17 220	.06 .09 206	.08 .13 155
39 N 127 W	.09 .17 134	.06 .09 173	.07 .13 167	.05 .10 213	.05 .10 173	.05 .10 182	.04 .08 222	.03 .07 244	.04 .09 196	.05 .12 197	.08 .10 174	.08 .13 141
39 N 128 W	.07 .14 138	.10 .11 135	.07 .13 169	.06 .11 164	.04 .10 161	.04 .09 167	.03 .07 233	.03 .07 219	.03 .07 227	.05 .10 171	.07 .20 163	.08 .11 136
39 N 129 W	.07 .11 133	.10 .10 162	.07 .10 202	.05 .09 229	.04 .06 249	.03 .06 254	.02 .06 288	.03 .06 248	.03 .07 238	.06 .09 178	.06 .09 184	.07 .09 172
39 N 130 W	.07 .08 304	.07 .07 337	.05 .07 248	.03 .07 349	.03 .04 451	.02 .04 339	.02 .05 356	.02 .05 324	.03 .06 251	.06 .10 239	.07 .09 187	.05 .07 335
39 N 131 W	.13 .13 138	.11 .13 149	.06 .08 192	.04 .05 215	.04 .04 347	.03 .05 264	.02 .04 400	.02 .03 357	.04 .07 284	.06 .08 187	.09 .09 198	.08 .10 174
39 N 132 W	.10 .12 135	.13 .15 101	.10 .12 157	.06 .08 163	.05 .07 185	.04 .05 251	.02 .04 269	.03 .06 219	.04 .06 235	.04 .07 159	.09 .10 172	.13 .14 148
39 N 133 W	.12 .18 132	.10 .21 112	.08 .11 145	.06 .11 149	.05 .08 162	.03 .05 206	.03 .04 240	.03 .05 186	.04 .04 246	.05 .06 316	.09 .08 220	.08 .11 150
40 N 124 W	.03 .09 727	.03 .06 710	.03 .07 747	.02 .05 736	.02 .05 853	.02 .04 605	.03 .05 658	.05 .06 517	.02 .04 478	.02 .06 490	.02 .07 525	.04 .08 454
40 N 125 W	.07 .15 178	.07 .14 168	.05 .11 184	.04 .11 210	.05 .12 167	.04 .09 223	.05 .09 212	.04 .09 233	.04 .11 193	.03 .12 191	.05 .11 213	.07 .15 151
40 N 126 W	.09 .18 111	.06 .28 75	.11 .19 80	.05 .13 102	.10 .14 124	.06 .17 105	.05 .12 127	.04 .11 127	.05 .13 95	.06 .13 114	.07 .17 128	.09 .23 101
40 N 127 W	.09 .14 127	.09 .13 122	.13 .16 115	.05 .11 165	.04 .09 167	.03 .08 196	.04 .09 204	.03 .06 270	.04 .09 162	.05 .12 169	.07 .16 122	.08 .13 123
40 N 128 W	.06 .12 287	.09 .14 162	.10 .11 153	.05 .08 212	.03 .08 201	.03 .21 248	.02 .07 301	.03 .06 247	.04 .08 205	.05 .09 190	.08 .12 136	.08 .09 225
40 N 129 W	.07 .10 167	.06 .11 189	.05 .07 276	.05 .07 305	.04 .05 279	.03 .06 230	.03 .05 268	.04 .06 249	.05 .08 243	.04 .08 253	.08 .09 218	.07 .11 158
40 N 130 W	.07 .08 209	.06 .07 295	.05 .05 568	.04 .05 479	.03 .04 519	.02 .04 519	.02 .05 499	.02 .06 393	.04 .06 359	.04 .05 472	.05 .06 396	.05 .08 197
40 N 131 W	.10 .15 108	.11 .12 156	.08 .10 145	.07 .08 168	.05 .15 191	.03 .06 185	.04 .05 216	.02 .04 245	.05 .06 170	.07 .07 147	.08 .10 153	.11 .12 129
40 N 132 W	.11 .10 165	.10 .09 162	.08 .10 182	.05 .07 183	.05 .06 232	.02 .04 261	.02 .04 304	.02 .03 271	.04 .05 233	.13 .08 213	.08 .09 177	.10 .13 173
40 N 133 W	.09 .11 172	.17 .09 166	.08 .08 226	.04 .06 291	.04 .05 268	.02 .03 384	.02 .03 375	.02 .04 341	.03 .04 429	.11 .06 362	.08 .07 235	.09 .11 203
41 N 124 W	.08 .17 102	.04 .10 112	.05 .12 101	.05 .21 114	.05 .12 125	.04 .11 120	.08 .14 114	.02 .06 180	.02 .06 208	.03 .06 212	.04 .08 209	.07 .07 178
41 N 125 W	.06 .16 204	.05 .14 227	.03 .09 256	.03 .11 225	.03 .10 243	.03 .09 258	.04 .09 271	.03 .08 236	.03 .10 236	.04 .11 271	.03 .11 246	.11 .17 192
41 N 126 W	.17 .16 77	.09 .19 77	.12 .29 82	.08 .15 93	.04 .16 102	.05 .14 87	.12 .29 84	.06 .14 87	.04 .18 91	.08 .27 118	.05 .15 101	.10 .19 98
41 N 127 W	.12 .22 88	.16 .17 84	.16 .26 79	.12 .17 117	.04 .10 105	.08 .18 66	.07 .14 64	.06 .12 85	.09 .20 60	.07 .15 82	.11 .19 94	.14 .21 84
41 N 128 W	.29 .25 77	.13 .14 60	.20 .36 66	.06 .09 101	.08 .13 69	.06 .13 76	.04 .13 83	.04 .14 77	.05 .12 65	.08 .12 89	.16 .24 83	.14 .14 86
41 N 129 W	.13 .18 103	.12 .18 97	.50 .43 108	.06 .08 120	.06 .09 119	.03 .06 154	.03 .07 137	.05 .07 122	.04 .09 118	.09 .11 111	.10 .12 107	.20 .14 113
41 N 130 W	.18 .14 113	.11 .16 156	.11 .09 164	.04 .05 216	.04 .06 218	.03 .05 274	.02 .05 253	.02 .05 295	.05 .06 199	.08 .08 206	.08 .10 154	.10 .15 122
41 N 131 W	.09 .12 175	.12 .16 202	.09 .10 221	.05 .06 289	.04 .06 268	.02 .04 270	.05 .11 344	.03 .03 341	.04 .05 247	.05 .08 227	.08 .12 195	.09 .11 161
41 N 132 W	.10 .12 116	.14 .18 113	.10 .12 115	.08 .09 155	.08 .09 161	.05 .05 161	.03 .05 171	.04 .07 152	.06 .07 148	.09 .08 162	.12 .11 139	.12 .17 131
41 N 133 W	.12 .16 117	.12 .18 99	.13 .16 115	.07 .09 133	.08 .08 118	.04 .05 157	.04 .26 152	.03 .05 168	.05 .07 141	.08 .11 137	.15 .12 113	.10 .13 123

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
42 N 124 W	.08	.06	.06	.05	.05	.05	.05	.05	.03	.02	.07	.06
	.15	.14	.12	.15	.13	.09	.13	.13	.10	.09	.17	.12
	103	107	74	92	96	112	128	90	112	112	88	76
42 N 125 W	.06	.06	.04	.03	.04	.03	.03	.03	.03	.03	.03	.06
	.12	.11	.08	.11	.14	.10	.09	.09	.10	.08	.10	.15
	221	241	273	259	214	303	296	238	243	268	272	196
42 N 126 W	.17	.15	.15	.08	.08	.06	.07	.04	.08	.10	.09	.17
	.28	.25	.21	.14	.15	.13	.17	.12	.21	.23	.15	.23
	73	60	77	80	75	61	63	76	50	73	77	58
42 N 127 W	.18	.09	.18	.10	.05	.07	.08	.06	.08	.11	.12	.14
	.21	.17	.23	.21	.09	.11	.12	.11	.18	.15	.15	.16
	86	82	95	89	83	73	72	64	69	94	114	102
42 N 128 W	.24	.10	.23	.10	.07	.10	.06	.07	.09	.08	.14	.16
	.20	.18	.24	.13	.14	.25	.15	.18	.11	.13	.25	.20
	94	64	87	68	70	67	67	61	53	82	86	110
42 N 129 W	.12	.10	.06	.06	.06	.04	.04	.02	.11	.14	.11	.10
	.16	.13	.09	.07	.07	.07	.06	.05	.13	.19	.13	.11
	212	166	260	244	241	157	143	264	48	61	152	257
42 N 130 W	.10	.14	.12	.07	.05	.04	.04	.32	.21	.12	.12	.14
	.14	.17	.12	.09	.09	.07	.09	.39	.09	.12	.10	.19
	146	142	124	93	100	139	128	100	52	76	137	114
42 N 131 W	.07	.14	.07	.07	.05	.04	.03	.02	.05	.10	.10	.13
	.09	.13	.10	.05	.07	.05	.04	.04	.07	.09	.13	.12
	187	158	199	216	160	183	280	288	206	166	158	138
42 N 132 W	.13	.11	.15	.08	.05	.04	.03	.04	.04	.08	.12	.12
	.17	.18	.13	.09	.05	.05	.05	.05	.06	.09	.19	.21
	121	120	123	185	194	228	249	234	190	159	116	126
42 N 133 W	.15	.16	.13	.07	.06	.05	.03	.03	.04	.08	.15	.12
	.15	.18	.10	.09	.07	.08	.04	.03	.05	.07	.17	.15
	144	110	167	181	256	257	233	259	219	200	119	139
43 N 124 W	.11	.09	.06	.03	.06	.03	.03	.03	.02	.02	.08	.07
	.14	.11	.12	.12	.10	.07	.10	.09	.06	.08	.21	.13
	95	100	80	84	87	104	92	76	123	103	72	104
43 N 125 W	.06	.04	.06	.03	.03	.02	.02	.02	.02	.10	.04	.06
	.13	.13	.10	.09	.09	.07	.06	.06	.09	.07	.09	.15
	254	272	255	241	241	280	304	213	281	456	423	224
43 N 126 W	.13	.13	.15	.13	.06	.06	.07	.03	.07	.07	.13	.12
	.19	.22	.14	.12	.14	.17	.16	.17	.21	.12	.15	.23
	71	58	61	59	59	41	42	52	47	87	77	68
43 N 127 W	.24	.13	.12	.10	.06	.06	.04	.11	.07	.09	.11	.20
	.33	.22	.20	.18	.09	.13	.10	.17	.14	.13	.15	.25
	71	64	84	64	64	48	58	54	53	105	110	83
43 N 128 W	.18	.23	.30	.11	.06	.04	.09	.05	.07	.09	.14	.16
	.21	.31	.22	.14	.11	.08	.11	.08	.12	.17	.15	.22
	85	78	75	68	69	64	64	54	71	88	104	105
43 N 129 W	.14	.16	.14	.09	.12	.09	.05	.05	.07	.12	.15	.13
	.17	.21	.15	.13	.13	.23	.08	.10	.08	.17	.18	.23
	136	98	123	93	97	87	76	86	77	82	105	107
43 N 130 W	.18	.08	.08	.05	.03	.02	.02	.02	.03	.09	.12	.07
	.10	.12	.10	.08	.05	.05	.05	.04	.05	.10	.12	.10
	330	156	306	317	346	369	320	330	288	173	118	332
43 N 131 W	.12	.10	.11	.11	.05	.04	.04	.02	.06	.10	.11	.19
	.15	.14	.11	.14	.10	.05	.06	.05	.09	.09	.12	.22
	119	149	139	117	133	150	150	169	126	130	116	103
43 N 132 W	.15	.12	.13	.11	.10	.07	.05	.05	.08	.14	.19	.17
	.19	.26	.15	.16	.09	.08	.07	.08	.10	.12	.20	.22
	99	101	114	95	85	83	94	84	75	81	78	79
43 N 133 W	.14	.12	.09	.09	.08	.04	.04	.06	.07	.09	.13	.20
	.13	.17	.10	.09	.09	.06	.05	.05	.07	.12	.12	.47
	127	112	117	147	122	128	115	129	100	149	143	121
44 N 124 W	.09	.08	.09	.04	.03	.01	.02	.01	.03	.03	.04	.11
	.17	.10	.16	.08	.06	.07	.05	.05	.05	.08	.09	.16
	126	133	118	136	162	133	161	95	138	156	174	94
44 N 125 W	.07	.05	.05	.03	.06	.02	.01	.01	.01	.02	.03	.08
	.14	.10	.09	.08	.07	.06	.05	.05	.04	.07	.06	.18
	229	252	305	237	259	271	341	286	540	492	437	221
44 N 126 W	.17	.14	.09	.18	.06	.05	.05	.02	.10	.16	.09	.17
	.23	.25	.16	.65	.10	.12	.17	.09	.24	.19	.13	.32
	84	45	68	52	73	63	61	76	39	80	76	65
44 N 127 W	.20	.23	.13	.14	.08	.08	.05	.04	.10	.13	.09	.17
	.28	.23	.21	.17	.12	.11	.15	.09	.12	.16	.14	.30
	75	62	77	55	77	55	42	64	61	77	103	81
44 N 128 W	.19	.16	.15	.10	.06	.27	.05	.05	.05	.05	.07	.25
	.22	.23	.17	.10	.11	.47	.11	.08	.10	.07	.12	.22
	99	124	103	90	109	83	79	74	124	288	270	103
44 N 129 W	.15	.14	.16	.10	.07	.05	.04	.04	.05	.07	.16	.18
	.18	.17	.17	.13	.06	.11	.07	.08	.08	.11	.12	.22
	99	94	115	125	102	107	104	94	119	168	145	139
44 N 130 W	.10	.11	.16	.10	.09	.07	.04	.06	.05	.09	.13	.16
	.14	.15	.16	.15	.14	.20	.09	.09	.09	.14	.20	.19
	134	116	126	102	110	110	110	91	113	125	117	117
44 N 131 W	.10	.09	.07	.05	.04	.02	.02	.05	.03	.04	.06	.13
	.12	.10	.07	.05	.06	.04	.04	.03	.05	.07	.08	.14
	231	194	318	256	288	417	3[illegible]4	385	381	372	273	238
44 N 132 W	.12	.11	.11	.07	.06	.05	.03	.03	.05	.08	.13	.11
	.14	.17	.11	.07	.08	.06	.05	.05	.08	.10	.12	.17
	170	150	167	1[illegible]1	177	169	175	149	143	173	151	177
44 N 133 W	.14	.15	.13	.12	.07	.08	.06	.04	.07	.11	.13	.11
	.16	.16	.12	.11	.07	.07	.06	.07	.10	.10	.14	.15
	137	133	118	101	105	110	108	109	100	137	116	135

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
45 N	.11	.06	.06	.04	.04	.01	.01	.01	.02	.04	.10	.11
124 W	.12	.08	.09	.09	.06	.04	.05	.04	.07	.07	.12	.14
	175	188	164	150	219	230	204	182	161	211	175	141
45 N	.06	.04	.06	.04	.03	.01	.01	.01	.01	.03	.05	.10
125 W	.10	.08	.10	.06	.05	.05	.04	.04	.03	.06	.10	.14
	277	338	329	277	344	349	368	238	422	458	355	233
45 N	.13	.08	.14	.07	.05	.03	.05	.05	.09	.14	.11	.18
126 W	.24	.12	.18	.15	.08	.08	.13	.08	.12	.10	.16	.27
	109	116	83	87	103	129	87	96	99	115	113	101
45 N	.19	.14	.12	.09	.06	.05	.06	.04	.06	.12	.11	.20
127 W	.26	.17	.17	.18	.11	.08	.11	.07	.12	.12	.15	.29
	98	101	115	82	104	75	81	81	72	110	132	86
45 N	.11	.13	.10	.09	.04	.05	.05	.03	.07	.17	.14	.29
128 W	.20	.14	.15	.21	.04	.07	.08	.07	.11	.15	.13	.27
	102	99	113	105	297	100	79	147	71	113	121	85
45 N	.14	.13	.11	.08	.06	.05	.05	.04	.08	.19	.12	.11
129 W	.19	.13	.16	.10	.09	.07	.08	.07	.08	.14	.18	.16
	119	97	144	109	100	115	97	95	123	117	131	109
45 N	.06	.06	.05	.04	.03	.03	.01	.03	.03	.06	.07	.08
130 W	.07	.08	.05	.05	.05	.03	.04	.03	.03	.06	.09	.10
	507	500	539	554	386	420	559	307	471	379	482	425
45 N	.08	.09	.07	.05	.04	.03	.09	.03	.05	.07	.10	.11
131 W	.10	.10	.07	.07	.06	.04	.04	.05	.07	.08	.12	.12
	257	273	284	223	260	251	274	222	209	216	199	255
45 N	.12	.12	.11	.08	.07	.04	.05	.05	.06	.10	.09	.18
132 W	.17	.12	.10	.08	.07	.06	.06	.06	.08	.11	.13	.16
	166	143	163	192	170	167	129	141	145	160	132	127
45 N	.23	.29	.23	.15	.16	.07	.08	.09	.07	.13	.16	.25
133 W	.29	.25	.22	.16	.12	.09	.08	.12	.09	.15	.18	.34
	61	53	59	59	55	68	56	45	56	93	79	75
46 N	.04	.04	.03	.03	.03	.02	.01	.01	.02	.03	.04	.06
124 W	.04	.06	.07	.05	.04	.03	.02	.02	.03	.05	.06	.08
	907	660	692	694	709	712	771	696	724	818	719	675
46 N	.09	.07	.08	.05	.03	.02	.02	.01	.04	.07	.07	.13
125 W	.10	.10	.08	.09	.05	.04	.04	.04	.06	.09	.12	.14
	220	222	269	204	246	291	314	255	269	285	258	154
46 N	.13	.13	.18	.09	.06	.07	.04	.04	.19	.11	.24	.27
126 W	.19	.19	.17	.13	.10	.13	.08	.08	.16	.27	.27	.21
	100	93	84	74	82	78	95	87	88	89	115	76
46 N	.14	.11	.11	.08	.05	.07	.05	.03	.06	.15	.12	.18
127 W	.16	.13	.14	.11	.05	.10	.09	.06	.11	.15	.14	.15
	126	120	140	108	100	96	102	98	95	105	181	114
46 N	.12	.16	.10	.08	.07	.05	.04	.05	.06	.11	.14	.12
128 W	.17	.15	.11	.10	.08	.08	.08	.06	.07	.12	.17	.13
	139	148	164	118	109	106	113	110	118	139	145	145
46 N	.16	.13	.12	.15	.05	.05	.05	.04	.05	.10	.10	.13
129 W	.17	.16	.11	.11	.09	.06	.06	.05	.09	.14	.12	.18
	145	136	154	129	116	115	107	120	113	133	136	145
46 N	.11	.14	.11	.15	.06	.06	.05	.05	.09	.14	.12	.13
13 W	.14	.16	.12	.12	.06	.08	.07	.08	.12	.11	.12	.16
	131	130	152	123	120	140	114	98	102	123	137	130
46 N	.14	.12	.11	.07	.05	.04	.04	.05	.08	.13	.15	.12
131 W	.15	.16	.15	.10	.08	.05	.07	.05	.08	.13	.17	.12
	141	107	112	158	157	142	123	144	141	125	154	148
46 N	.10	.09	.09	.08	.03	.06	.14	.06	.07	.09	.13	.16
132 W	.10	.09	.08	.08	.05	.06	.12	.08	.08	.12	.14	.17
	240	182	254	295	229	145	138	121	151	121	114	134
46 N	.15	.17	.15	.12	.14	.07	.06	.05	.10	.13	.17	.24
133 W	.14	.20	.15	.12	.14	.08	.09	.06	.13	.12	.18	.23
	106	92	83	95	92	77	74	86	90	105	91	108
47 N	.18	.10	.07	.08	.04	.02	.02	.02	.03	.10	.07	.18
124 W	.15	.11	.10	.10	.09	.03	.03	.04	.04	.06	.09	.19
	80	96	81	83	84	117	119	80	101	102	173	74
47 N	.10	.08	.06	.07	.04	.02	.01	.01	.03	.04	.07	.11
125 W	.12	.10	.08	.09	.05	.03	.02	.02	.03	.17	.09	.15
	228	198	252	195	197	356	450	436	274	357	304	155
47 N	.14	.12	.10	.09	.05	.06	.03	.03	.09	.09	.10	.12
126 W	.16	.13	.11	.10	.08	.08	.06	.06	.10	.11	.11	.14
	196	158	177	185	174	152	143	174	157	192	223	138
47 N	.15	.10	.11	.08	.05	.08	.03	.05	.08	.07	.11	.14
127 W	.13	.12	.09	.12	.08	.11	.06	.06	.10	.10	.13	.13
	171	177	215	171	177	175	149	151	181	170	186	159
47 N	.15	.16	.09	.10	.06	.09	.08	.04	.06	.08	.10	.15
128 W	.12	.19	.12	.13	.06	.12	.06	.08	.10	.09	.19	.17
	151	127	156	130	128	119	108	116	183	293	154	125
47 N	.19	.21	.13	.09	.06	.06	.04	.05	.08	.09	.11	.16
129 W	.18	.20	.16	.13	.06	.08	.07	.08	.09	.10	.16	.18
	88	100	83	94	99	95	94	86	107	198	115	98
47 N	.10	.10	.10	.05	.05	.03	.02	.02	.07	.13	.19	.09
130 W	.12	.12	.09	.06	.05	.06	.03	.05	.06	.14	.21	.08
	262	283	299	276	213	247	270	242	257	148	78	282
47 N	.08	.12	.08	.06	.04	.03	.03	.03	.04	.11	.10	.10
131 W	.13	.16	.09	.08	.07	.04	.04	.05	.06	.11	.14	.12
	237	120	180	200	198	267	237	316	326	202	185	262
47 N	.11	.08	.09	.13	.04	.03	.03	.04	.04	.08	.08	.11
132 W	.16	.11	.10	.09	.06	.03	.04	.05	.06	.10	.10	.17
	159	206	171	157	265	374	292	259	232	257	248	196
47 N	.16	.18	.19	.11	.10	.08	.07	.06	.08	.11	.20	.18
133 W	.17	.19	.15	.17	.14	.11	.08	.10	.15	.12	.22	.17
	77	84	79	88	76	76	61	85	96	114	90	91

LAT/LON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
48 N 125 W	.06 .05 930	.06 .06 739	.04 .06 848	.03 .04 770	.02 .02 767	.01 .01 763	.01 .01 1213	.01 .02 1138	.02 .03 754	.03 .05 795	.05 .05 823	.07 .08 629
48 N 126 W	.12 .12 304	.11 .09 209	.10 .08 252	.07 .07 198	.06 .09 185	.05 .05 197	.02 .03 324	.02 .02 327	.03 .04 298	.07 .05 400	.09 .09 331	.12 .12 201
48 N 127 W	.12 .12 143	.12 .13 131	.10 .12 130	.09 .14 101	.08 .10 151	.06 .07 140	.06 .07 137	.04 .06 134	.04 .06 206	.09 .11 136	.09 .11 247	.17 .15 137
48 N 128 W	.12 .14 114	.11 .16 131	.09 .09 139	.06 .08 147	.06 .08 148	.05 .06 133	.05 .08 118	.05 .07 115	.08 .14 130	.13 .14 134	.14 .16 142	.15 .16 136
48 N 129 W	.12 .17 111	.14 .12 125	.10 .11 126	.07 .10 110	.06 .08 147	.05 .08 113	.05 .08 135	.04 .08 131	.08 .14 141	.11 .15 117	.13 .16 114	.13 .15 122
48 N 130 W	.14 .15 132	.11 .17 108	.09 .10 136	.13 .11 123	.07 .09 131	.45 .18 138	.06 .09 120	.04 .06 148	.08 .09 179	.10 .15 131	.14 .16 134	.15 .16 141
48 N 131 W	.19 .18 143	.11 .13 126	.11 .12 134	.05 .07 167	.05 .06 207	.04 .05 168	.03 .04 173	.04 .06 161	.07 .09 178	.10 .14 169	.11 .16 162	.10 .15 184
48 N 132 W	.08 .08 322	.07 .07 302	.06 .06 335	.05 .07 321	.03 .04 380	.03 .05 205	.04 .06 192	.04 .05 192	.07 .08 209	.13 .13 161	.11 .12 197	.08 .10 295
48 N 133 W	.12 .13 124	.14 .16 95	.13 .15 116	.08 .12 134	.08 .08 136	.07 .07 133	.04 .05 137	.06 .09 107	.10 .09 147	.13 .12 143	.12 .16 147	.15 .15 153
48 N 134 W	.16 .17 82	.18 .26 107	.15 .14 97	.13 .13 104	.08 .07 118	.06 .08 118	.05 .05 94	.08 .07 91	.10 .13 96	.22 .34 114	.13 .14 132	.28 .25 114
49 N 126 W	.20 .13 98	.09 .09 140	.23 .13 124	.08 .08 141	.06 .05 149	.06 .05 145	.03 .02 406	.02 .02 378	.05 .04 235	.07 .06 207	.09 .12 122	.15 .16 106
49 N 127 W	.12 .12 152	.09 .10 159	.10 .12 170	.08 .10 193	.06 .06 213	.05 .06 209	.04 .03 331	.03 .03 283	.06 .06 268	.08 .08 223	.26 .16 212	.12 .11 169
49 N 128 W	.13 .13 185	.08 .12 175	.10 .09 234	.06 .09 197	.04 .05 453	.04 .05 273	.04 .05 325	.04 .04 322	.06 .07 272	.10 .11 207	.10 .10 267	.14 .13 184
49 N 129 W	.11 .14 184	.10 .09 190	.09 .09 212	.05 .09 245	.05 .06 289	.04 .05 241	.04 .05 272	.03 .05 251	.05 .08 249	.09 .11 233	.09 .11 246	.13 .14 194
49 N 130 W	.13 .12 308	.09 .11 316	.06 .07 314	.06 .07 315	.04 .05 298	.03 .04 298	.03 .05 303	.03 .05 325	.05 .06 345	.07 .09 280	.07 .08 332	.11 .12 304
49 N 131 W	.09 .09 430	.09 .09 388	.06 .08 411	.05 .08 452	.04 .05 330	.02 .03 520	.04 .05 458	.03 .04 330	.05 .06 420	.05 .06 362	.07 .08 368	.07 .11 406
49 N 132 W	.15 .14 182	.10 .11 197	.10 .11 189	.09 .09 191	.05 .05 240	.06 .06 211	.03 .04 235	.04 .05 220	.06 .08 225	.09 .10 227	.11 .10 235	.12 .11 217
49 N 133 W	.11 .14 196	.10 .12 185	.11 .08 225	.07 .09 250	.06 .06 235	.04 .05 244	.03 .04 220	.04 .05 272	.06 .07 251	.11 .10 233	.13 .13 238	.11 .13 190
49 N 134 W	.14 .13 200	.12 .11 179	.10 .09 201	.09 .12 210	.05 .06 249	.05 .05 240	.04 .04 227	.04 .05 252	.07 .07 277	.11 .12 257	.11 .12 262	.11 .12 211
49 N 135 W	.12 .11 183	.11 .11 165	.10 .11 199	.09 .12 217	.08 .07 213	.08 .05 200	.05 .05 184	.05 .06 211	.06 .07 263	.08 .11 243	.09 .11 306	.11 .10 241
50 N 127 W	.38 .26 19	.17 .16 30	.28 .33 20	.55 .32 35	.09 .02 59	.09 .10 27	.05 .05 86	.04 .01 88	.03 .02 160	.10 .07 112	2.75 .51 53	.54 .55 17
50 N 128 W	.18 .17 68	.33 .35 48	.19 .13 68	.11 .17 69	.13 .13 62	.08 .10 95	.09 .08 102	.06 .09 69	.09 .12 77	.10 .10 81	.12 .17 84	.32 .27 61
50 N 129 W	.17 .20 93	.18 .16 78	.13 .17 89	.11 .15 110	.06 .07 136	.08 .09 116	.05 .06 171	.05 .07 148	.07 .11 129	.13 .14 98	.20 .18 106	.22 .24 82
50 N 130 W	.19 .14 124	.13 .13 113	.15 .14 121	.07 .10 140	.05 .06 189	.06 .06 210	.04 .07 216	.05 .07 183	.05 .09 187	.11 .11 152	.13 .20 139	.11 .13 110
50 N 131 W	.13 .17 163	.12 .13 149	.10 .11 160	.07 .10 217	.05 .06 253	.05 .06 202	.04 .05 273	.04 .05 240	.07 .09 248	.10 .10 180	.11 .12 187	.12 .15 154
50 N 132 W	.12 .16 138	.12 .13 129	.12 .10 160	.08 .08 173	.05 .06 223	.04 .06 213	.04 .05 254	.09 .23 234	.06 .08 228	.12 .15 148	.13 .12 170	.14 .23 125
50 N 133 W	.14 .16 125	.14 .14 129	.15 .13 137	.06 .08 189	.06 .06 212	.06 .07 185	.04 .05 214	.04 .05 230	.07 .08 203	.14 .12 166	.16 .15 147	.16 .17 144
50 N 134 W	.12 .11 327	.08 .10 261	.07 .06 331	.05 .08 309	.04 .05 328	.03 .04 409	.03 .04 335	.04 .04 313	.07 .08 203	.11 .11 163	.11 .10 284	.10 .12 289
50 N 135 W	.14 .15 161	.13 .11 162	.11 .11 197	.08 .08 212	.05 .05 255	.04 .04 263	.03 .04 237	.05 .06 237	.05 .06 484	.10 .11 228	.11 .13 222	.15 .15 188
50 N 136 W	.08 .08 485	.09 .08 463	.05 .05 649	.04 .05 681	.04 .04 595	.04 .04 537	.03 .03 384	.04 .04 406	.04 .06 446	.07 .08 499	.08 .07 536	.09 .09 566

APPENDIX III

Monthly Wind Stress Curl Distributions

The monthly mean wind stress curl distributions are displayed in Charts 37 to 48. The plotted values are estimates of the vertical component of the wind stress curl, calculated by applying a finite difference, spherical coordinate curl operator to the fields of monthly mean surface wind stress. The contoured values are plotted in units of dyne cm^{-2}per 100 km. A value of 1.0 dyne cm^{-2} per 100 km is equivalent to 1.0×10^{-7} dyne cm^{-3}. The contour interval is 0.25 dyne cm^{-2}per 100 km. Positive wind stress curl is associated with surface Ekman divergence (upwelling). Negative values are shaded. These correspond to surface Ekman convergence (downwelling).

In the following charts, the month is indicated in the figure legend in the upper right corner of the charts. The coastline configuration is superimposed on the grid as a visual aid and does not represent a conformal mapping.

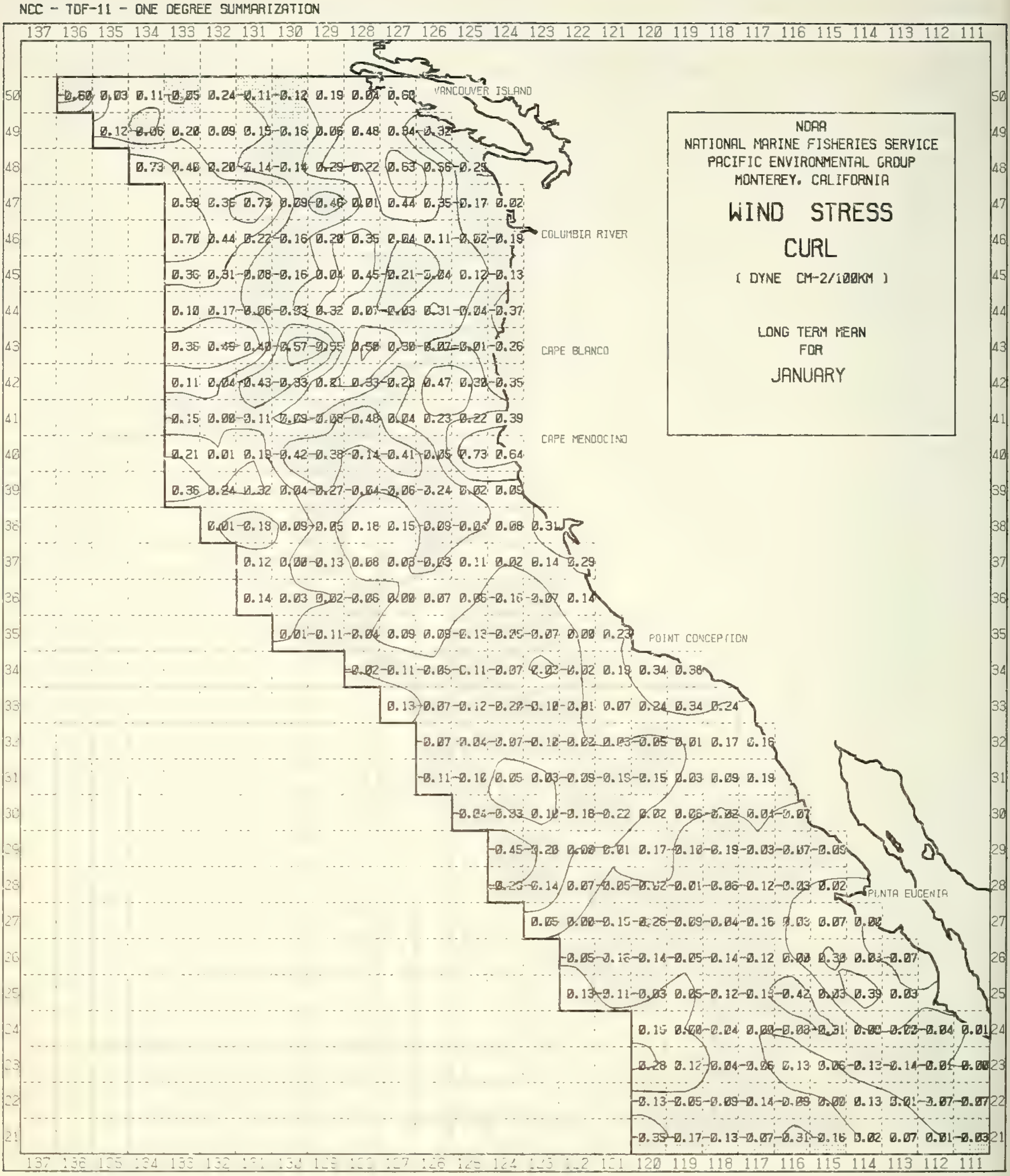


Chart 37.—Wind stress curl for January.

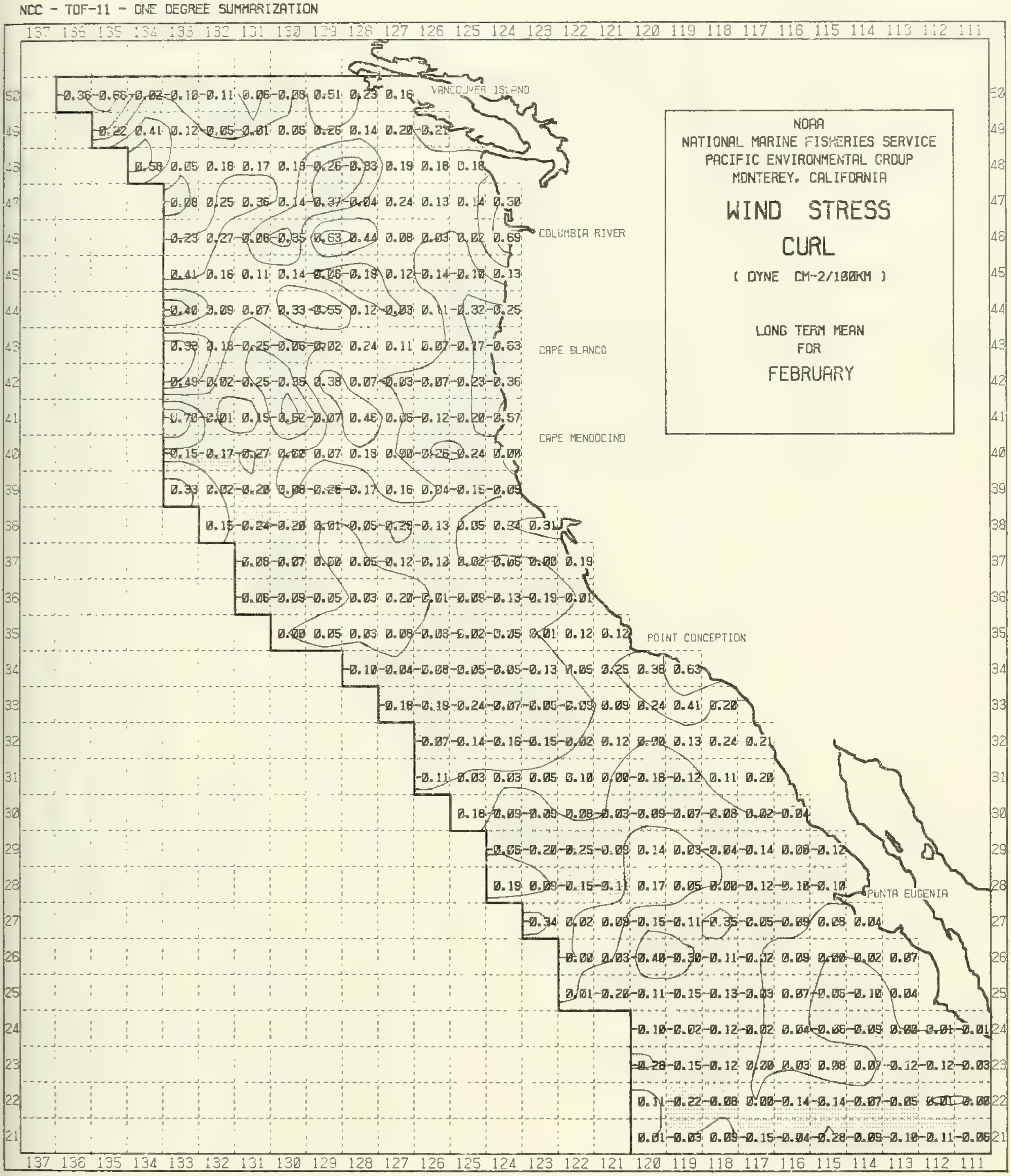


Chart 38.—Wind stress curl for February.

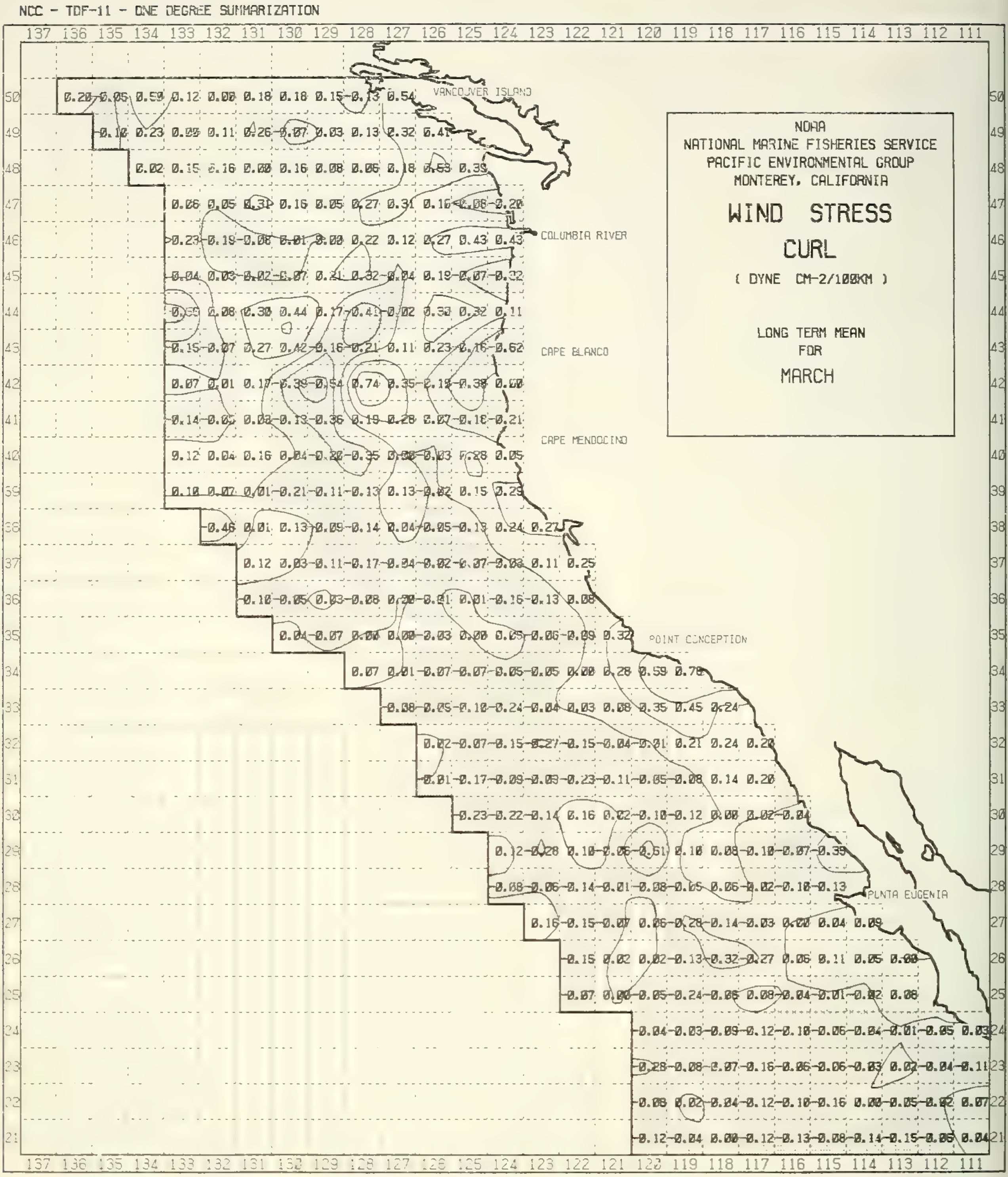


Chart 39.—Wind stress curl for March.

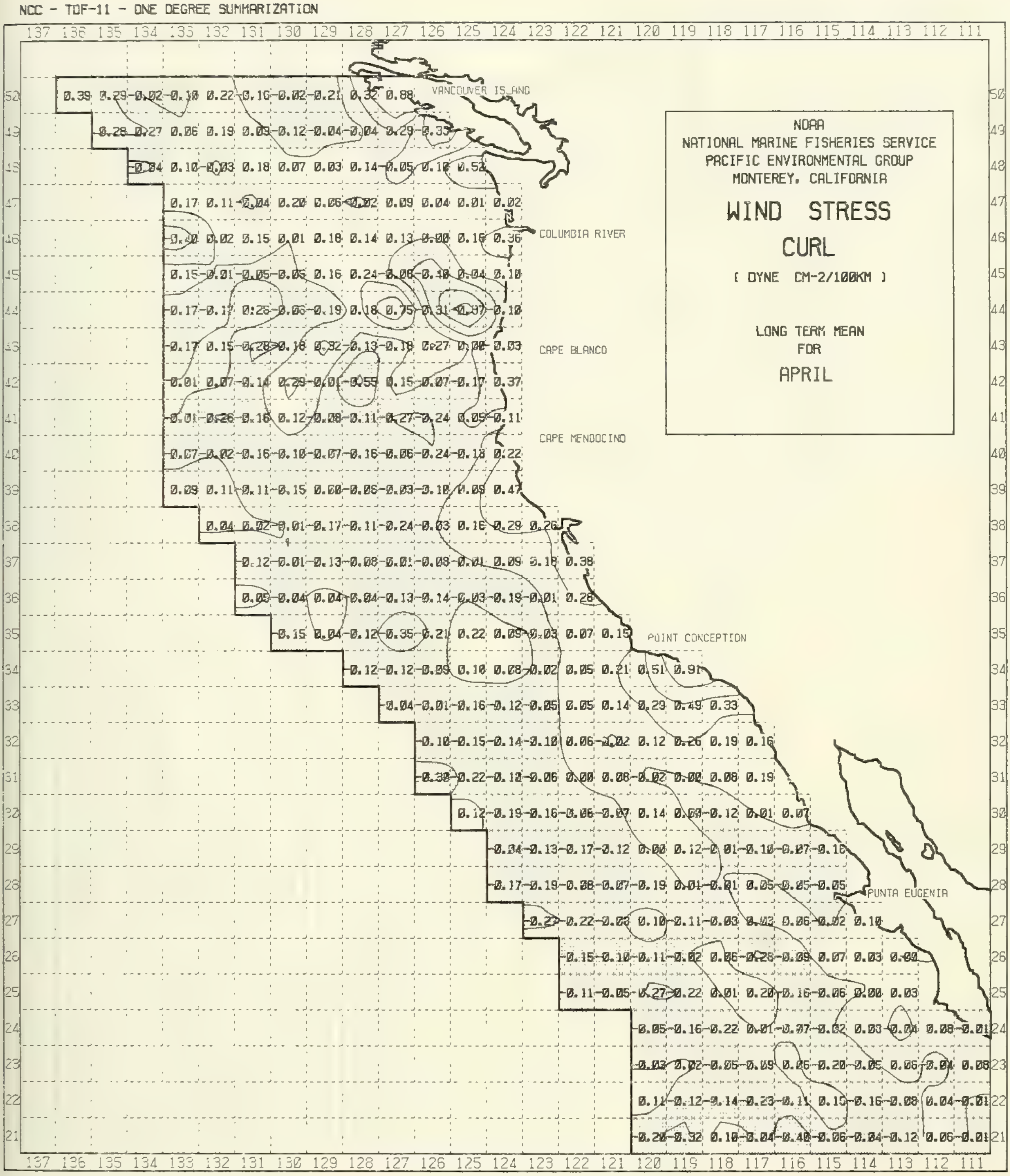


Chart 40.—Wind stress curl for April.

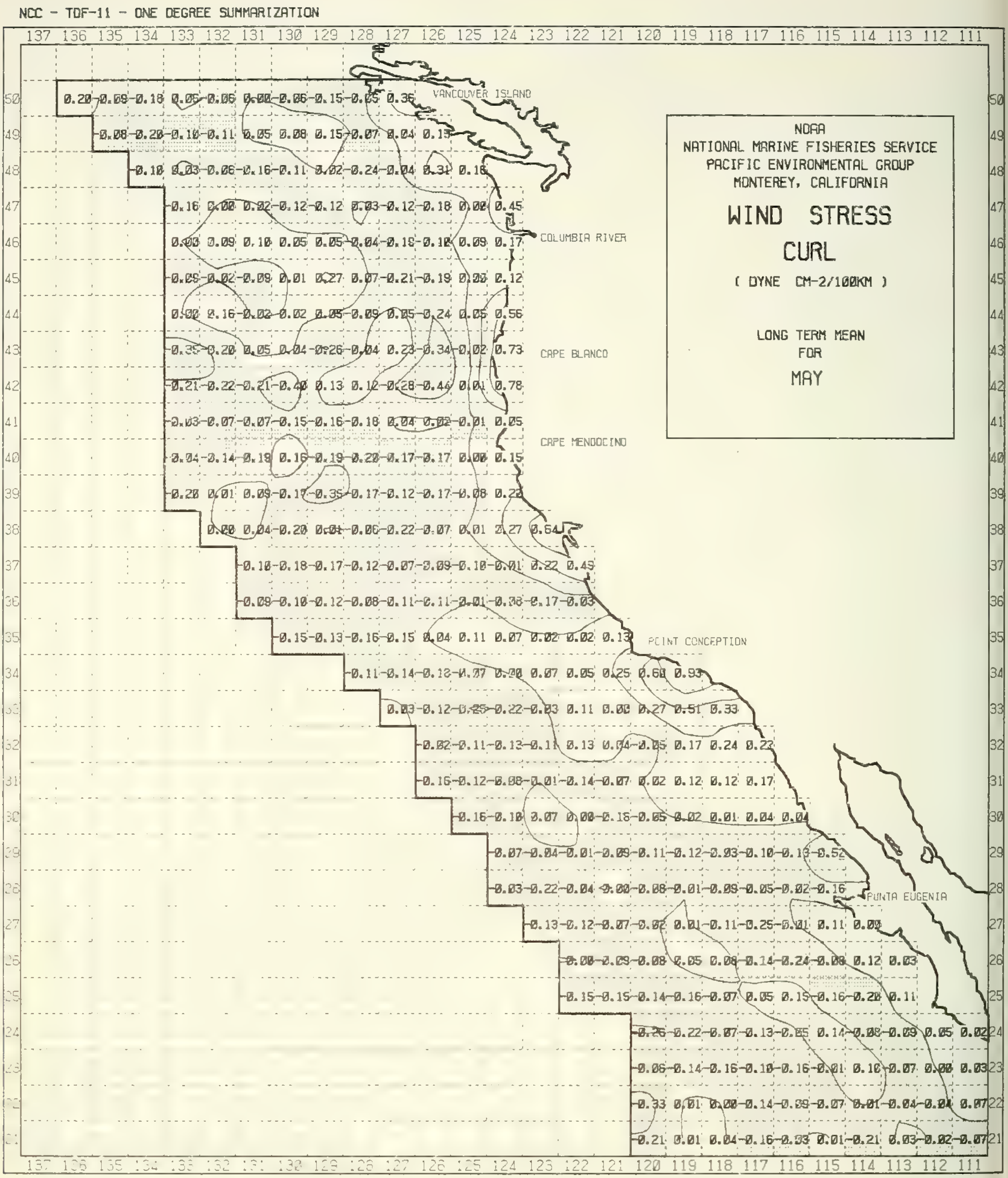


Chart 41.—Wind stress curl for May.

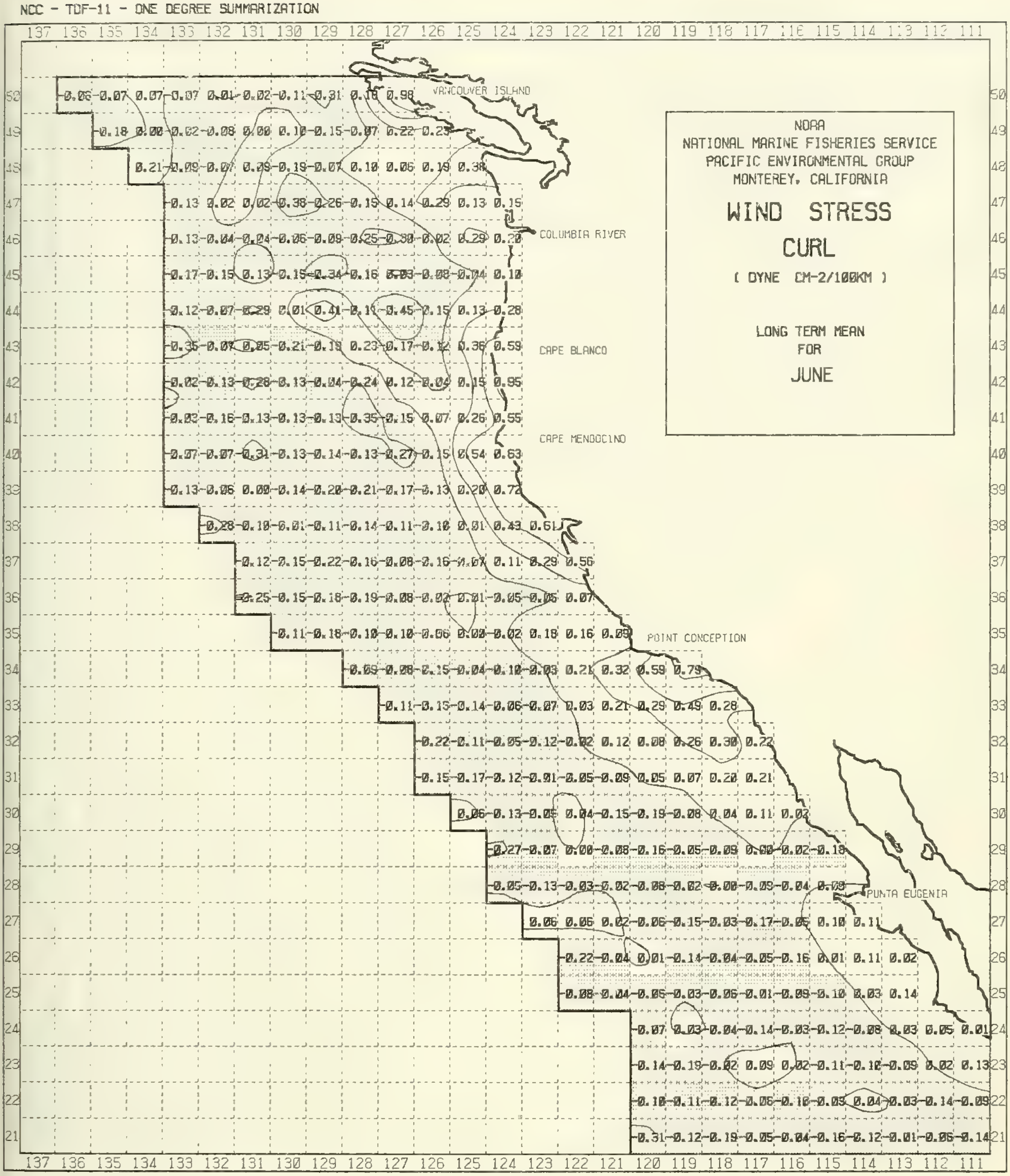


Chart 42.—Wind stress curl for June.

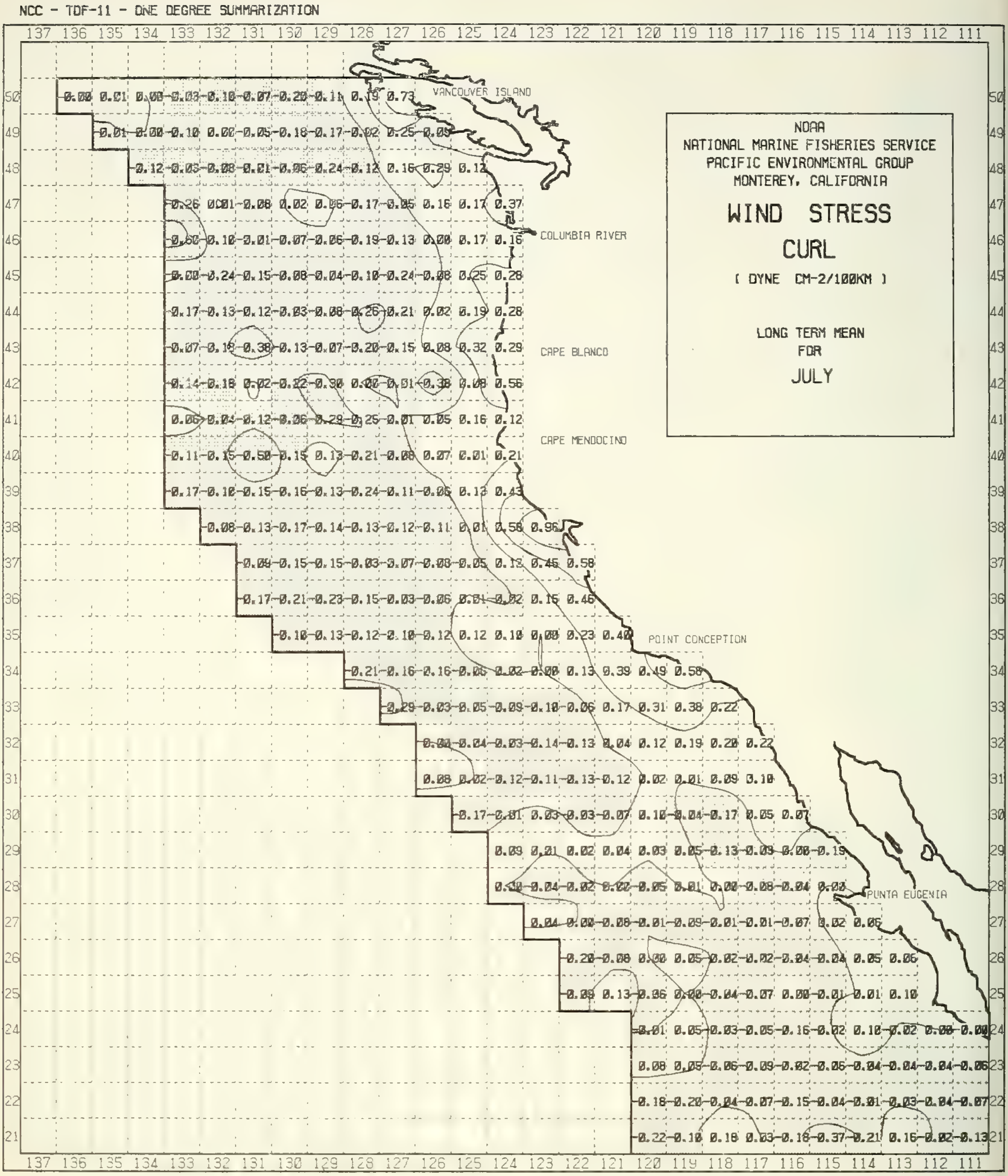


Chart 43.—Wind stress curl for July.

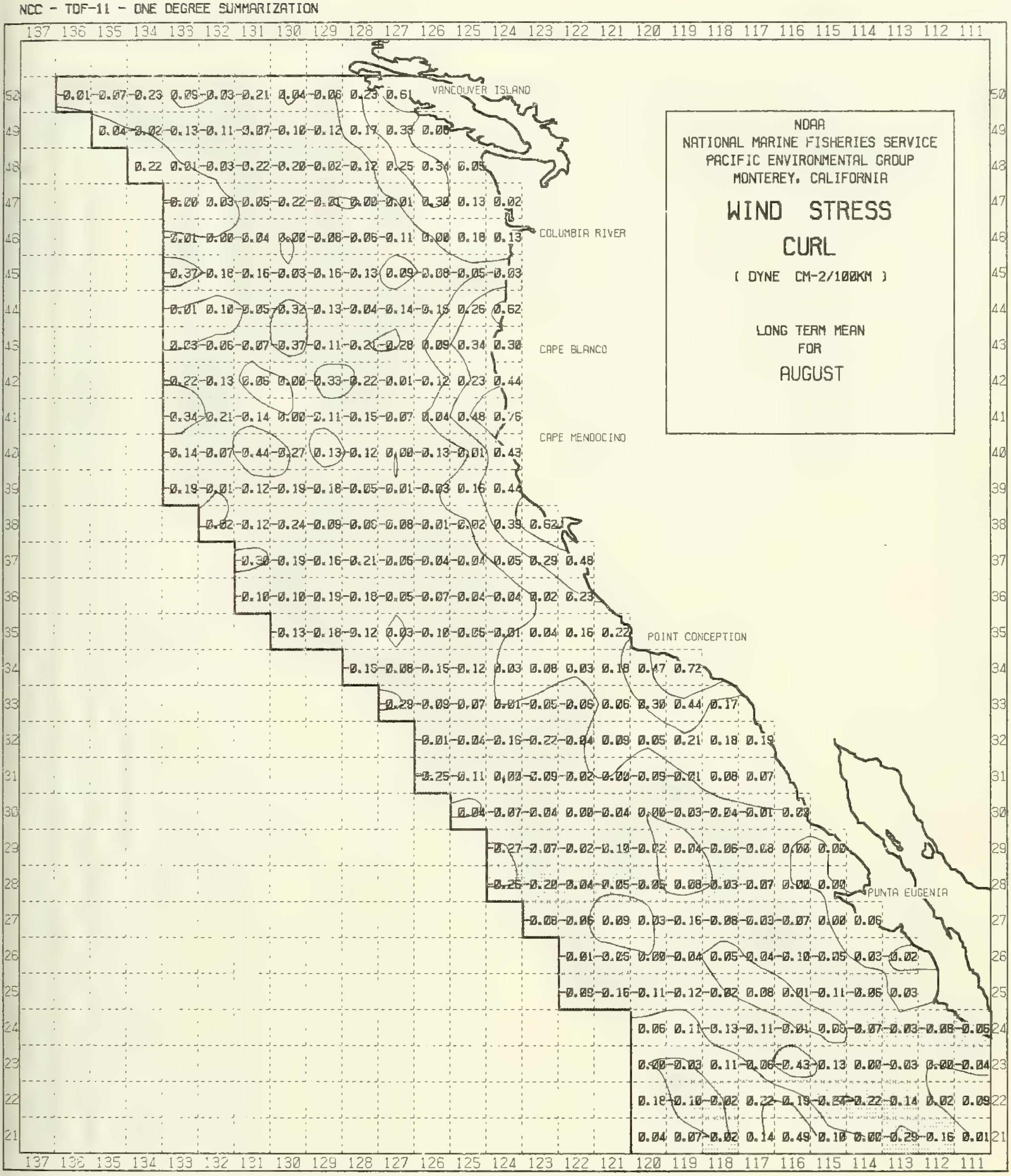


Chart 44.—Wind stress curl for August.

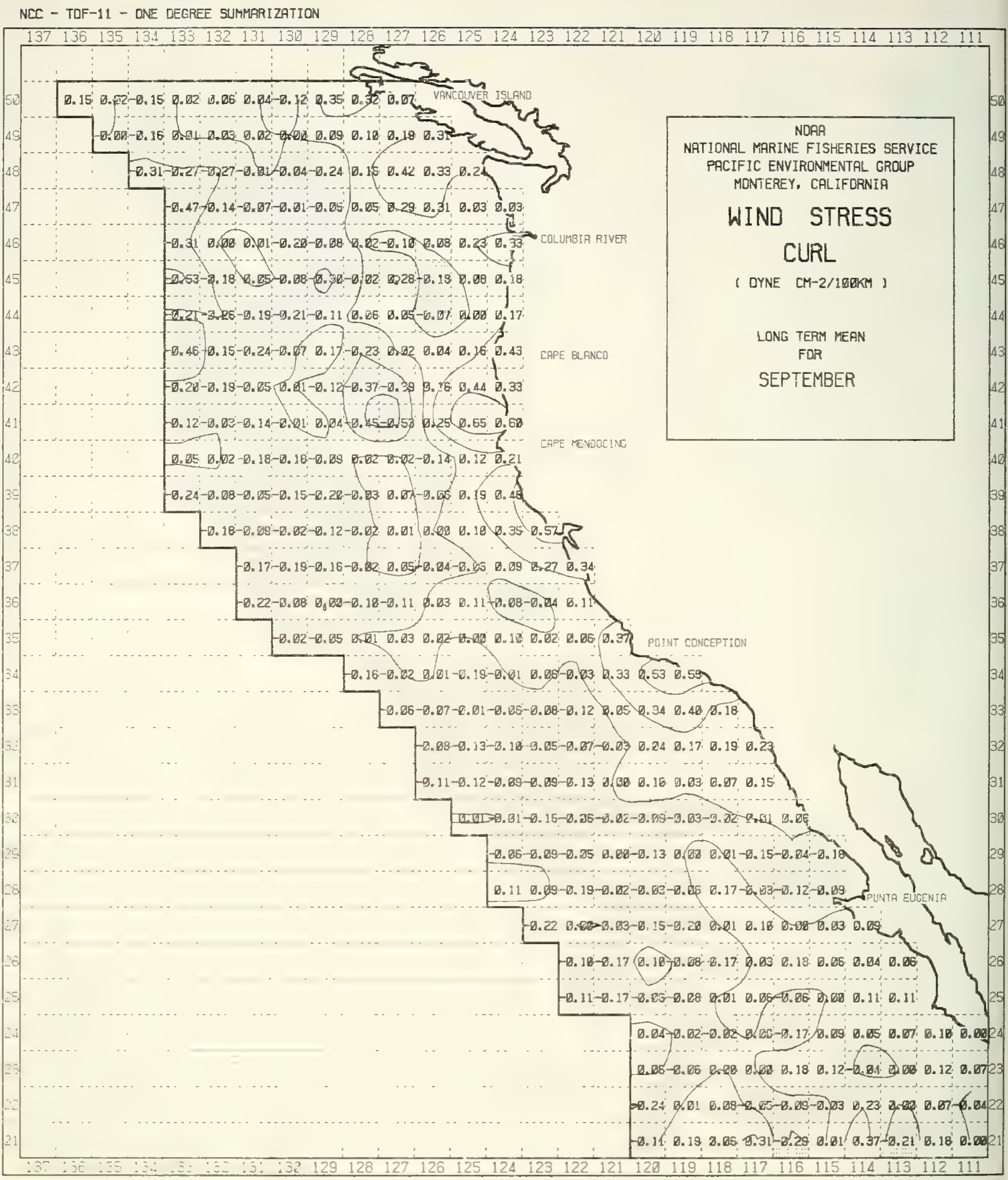


Chart 45.—Wind stress curl for September.

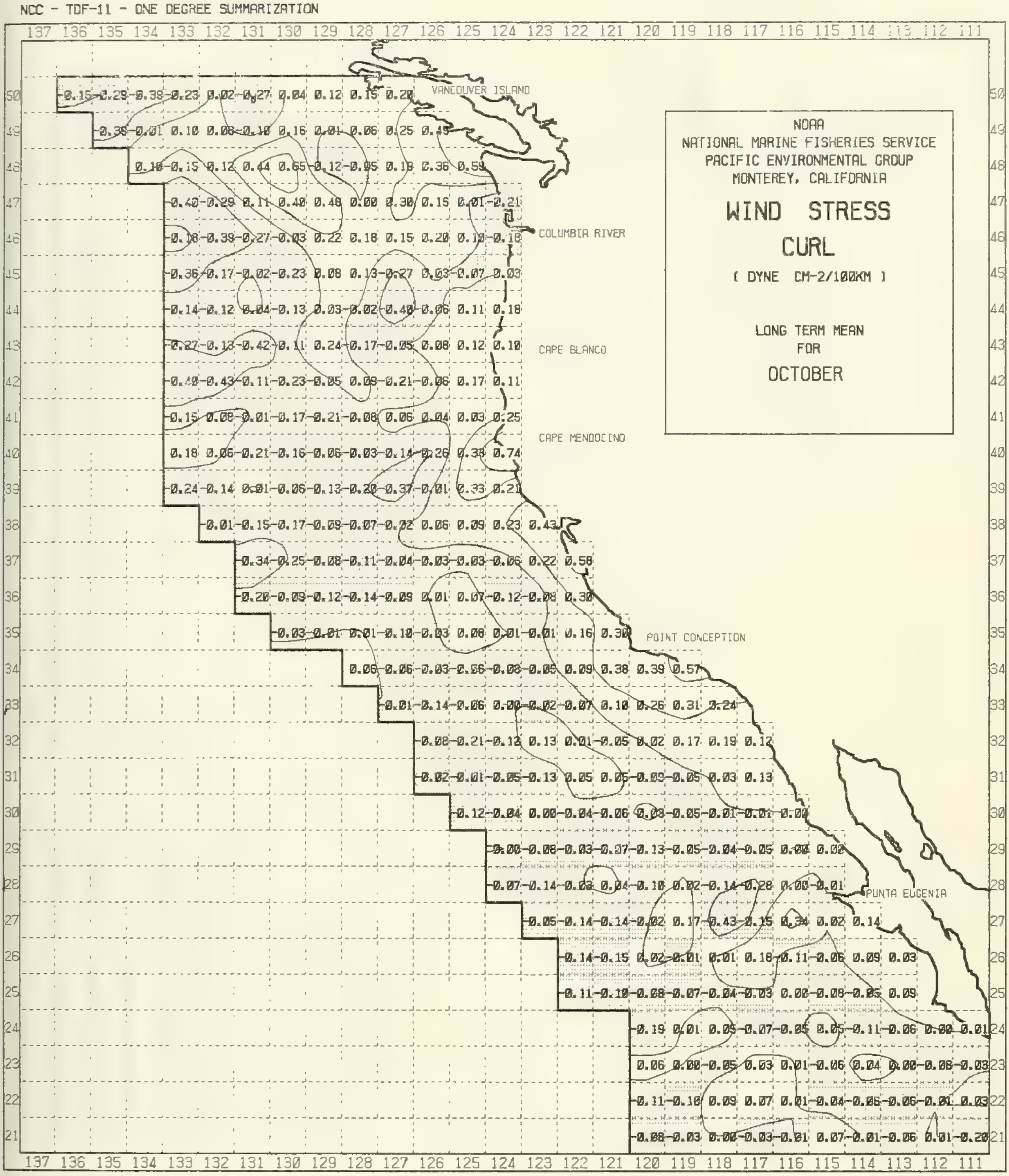


Chart 46.—Wind stress curl for October.

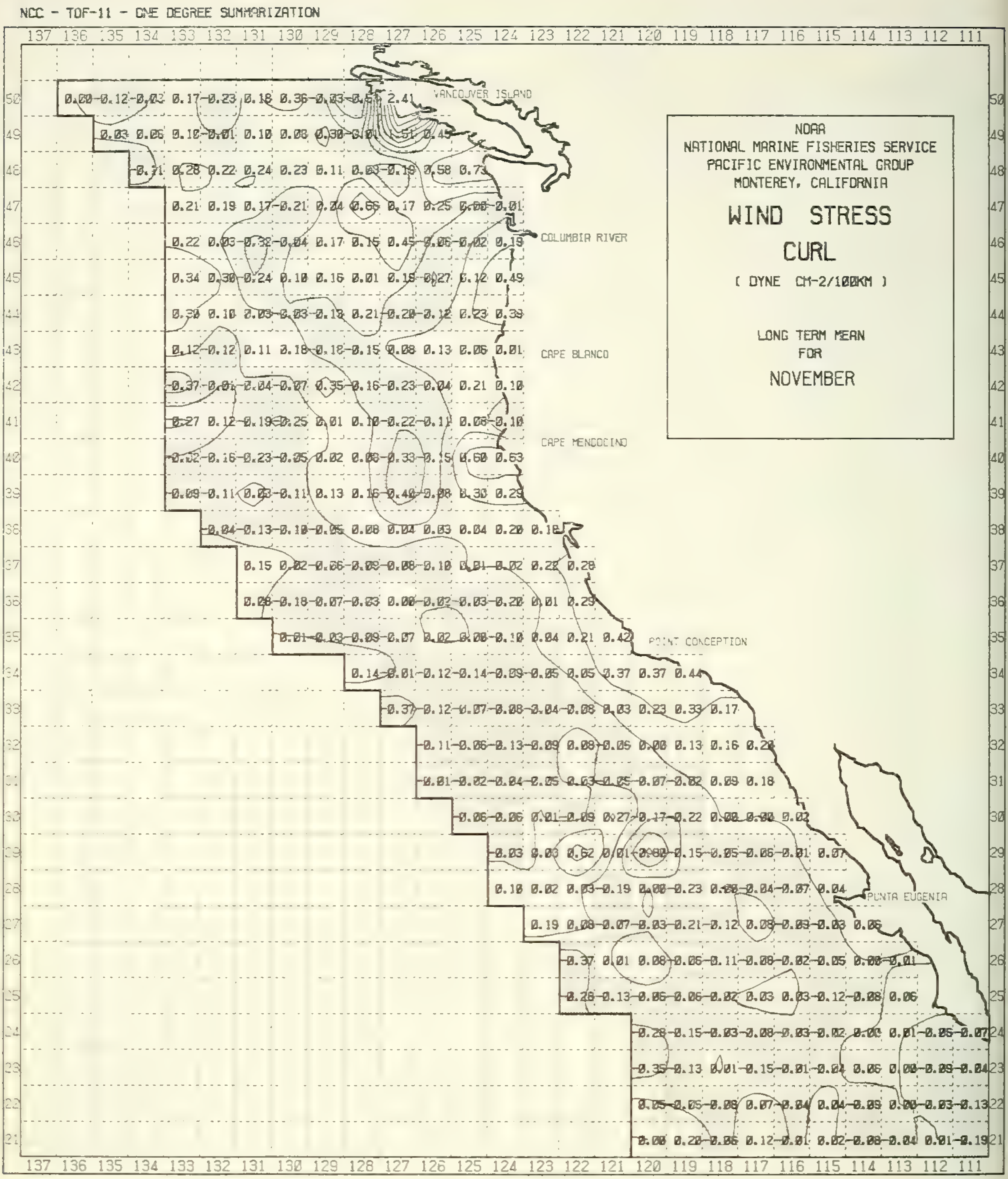


Chart 47.—Wind stress curl for November.

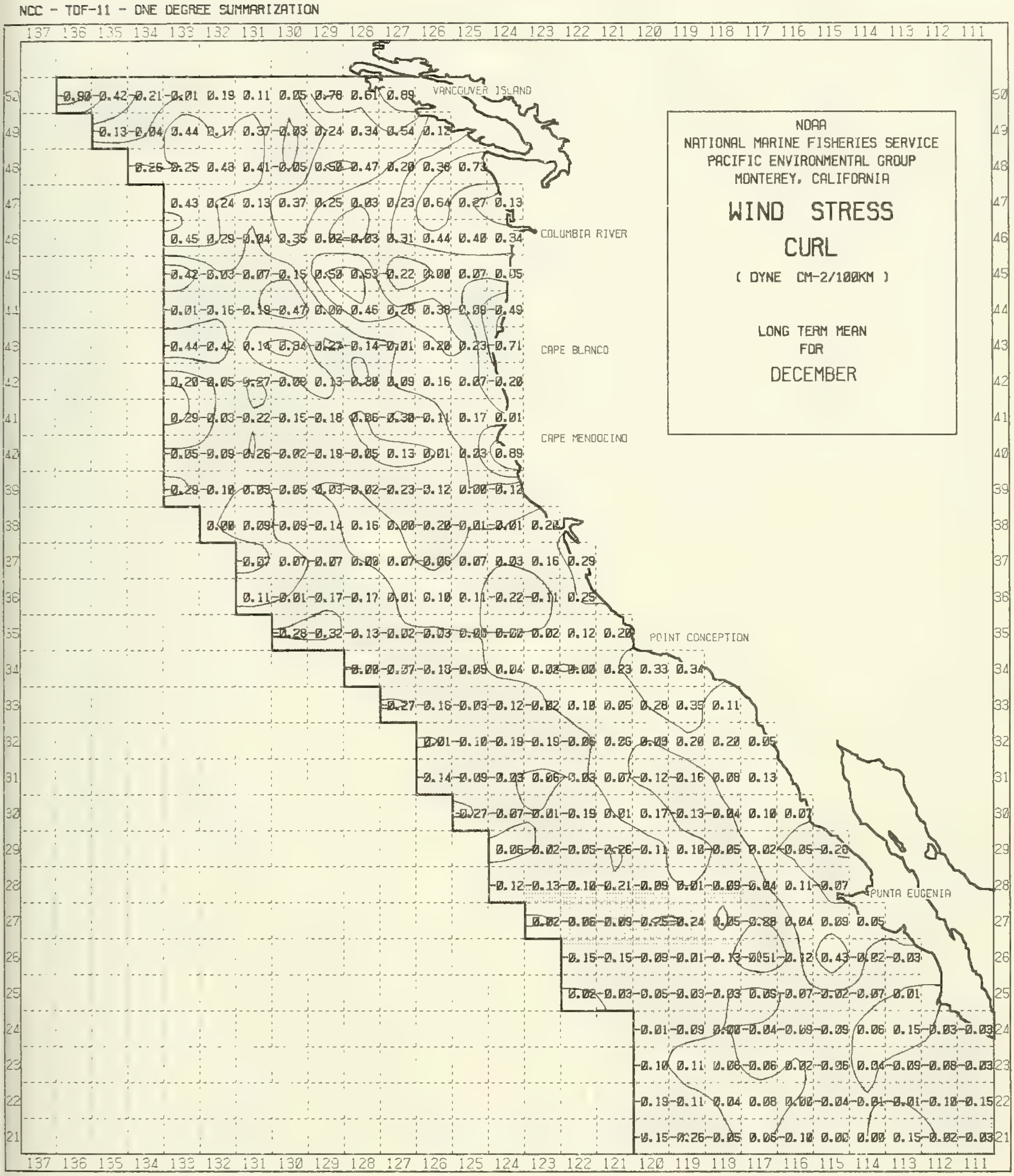


Chart 48.—Wind stress curl for December.

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672. Seasonal occurrence of young Guld menhaden and other fishes in a northwestern Florida estuary. By Marlin E. Tagatz and E. Peter H. Wilkins. August 1973, iii + 14 p., 1 fig., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

673. Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. By Frank W. Steimle, Jr. and Richard B. Stone. December 1973, iii + 50 p., 2 figs., 5 app. tables.

674. Lake Erie bottom trawl explorations, 1962-66. By Edgar W. Bowman. January 1974, iv + 21 p., 9 figs., 1 table, 7 app. tables.

675. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 1. Report of the Symposium. March 1975, iii + 33 p.; Part 2. Review and contributed papers. July 1974, iv + 355 p. (38 papers); Part 3. Species synopses. June 1975, iii + 159 p. (8 papers). Richard S. Shomura and Francis Williams (editors). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

676. Price spreads and cost analyses for finfish and shellfish products at different marketing levels. By Erwin S. Penn. March 1974, vi + 74 p., 15 figs., 12 tables, 12 app. figs., 14 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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689. Ocean distribution of stocks of Pacific salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdnerii*, as shown by tagging experiments. Charts of tag recoveries by Canada, Japan, and the United States, 1956-69. By Robert R. French, Richard G. Bakkala, and Doyle F. Sutherland. June 1975, viii + 89 p., 117 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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694. Semiclosed seawater system with automatic salinity, temperature and turbidity control. By Sid Korn. September 1975, iii + 5 p., 7 figs., 1 table.

695. Distribution, relative abundance, and movement of skipjack tuna, *Katsuwonus pelamis*, in the Pacific Ocean based on Japanese tuna longline catches, 1964-67. By Walter M. Matsumoto. October 1975, iii + 30 p., 15 figs., 4 tables.

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NOAA Technical Report NMFS SSRF-715

Bottom Obstructions in the Southwestern North Atlantic, Gulf of Mexico, and Caribbean Sea

G. Michael Russell, Abraham J. Barrett,
L. Steve Sarbeck, and John H. Wordlaw

September 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Continued on inside back cover

NOAA Technical Report NMFS SSRF-715

Bottom Obstructions in the Southwestern North Atlantic, Gulf of Mexico, and Caribbean Sea

G. Michael Russell, Abraham J. Barrett,
L. Steve Sarbeck, and John H. Wordlaw

September 1977

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Bottom Obstructions in the Southwestern North Atlantic, Gulf of Mexico, and Caribbean Sea[1]

G. MICHAEL RUSSELL, ABRAHAM J. BARRETT, L. STEVE SARBECK,
and JOHN H. WORDLAW[2]

ABSTRACT

Lists of bottom obstructions are provided to aid in avoiding potential hazards to fishing gear. Locations, depth, gear type, and damage received are included. Within the regions, the following numbers of obstructions are identified: 267 southeastern North America, 320 Gulf of Mexico, 23 West Indies, 119 Caribbean Sea, and 59 northeast coast of South America.

INTRODUCTION

Damage to fishing gear from bottom obstructions is costly in lost time and gear replacement or repair. To effectively reduce gear damage, fishermen keep their own records of obstructions encountered during fishing operations, but few of these personal records have been published. There are two additional sources for information on obstructions: Graham (1975) and the Obstruction Commission, Gulf State Marine Fisheries Commission, New Orleans, La.

Since 1950 the National Marine Fisheries Service (formerly Bureau of Commercial Fisheries) had located 788 obstructions during research cruises. This report provides fishermen, operating in the southwestern North Atlantic and adjacent areas, with locations of these obstructions. However, no attempt has been made to identify them.

DATA FORMAT

The southwestern North Atlantic has been divided into five regions to help find these obstructions: 1) southeastern North America, 2) Gulf of Mexico, 3) West Indies, 4) Caribbean Sea, and 5) northeastern South America.

Division between these regions is based on latitude and longitude, and major geographical features that form natural boundaries (Fig. 1). The location of obstructions within these five regions is arranged from north to south (latitude) or east to west (longitude), depending on a fisherman's orientation to the shoreline. Locations within regions 2 (Gulf of Mexico), 3 (West Indies), and 4 (Caribbean Sea) are listed from east to west (increasing longitude); locations within regions 1 (southeastern North America) and 5 (northeastern South America) are listed from north to south (decreasing latitude).

Information on depth, gear, and damage is also provided. Loran positions are included for those areas where readings are considered reliable.

APPLICATION

The area to be fished can be identified from the orientation chart (Fig. 1). If fishing is to be conducted in the Gulf of Mexico (region 2) then the longitude of the fishing area should be determined. The positions and depth of obstructions can then be obtained directly from the listing, including type of damage to gear.

Example: A fisherman plans to fish between lat. 29°00′ and 29°50′N and long. 80°30′ and 80°40′W. He finds the area is in southeastern North America, region 1 (Fig. 1). He then refers to the obstruction location listing for this region. The locations between lat. 29°00′ and 29°50′N are

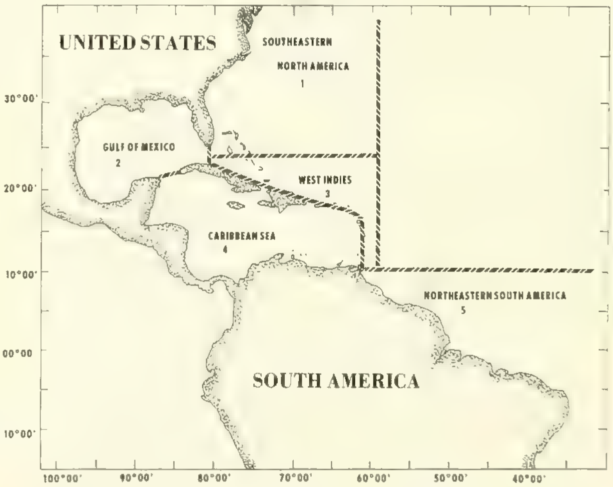

Figure 1.—Geographic boundaries of the five regions where obstructions have been located.

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[1] Contribution No. 77-08P from the Southeast Fisheries Center, Pascagoula Laboratory.

[2] Southeast Fisheries Center Pascagoula Laboratory, National Marine Fisheries Service, NOAA, P.O. Drawer 1207, Pascagoula, MS 39567.

blocked off. The obstructions located between long. 80°30′ and 80°40′W can then be easily marked and located on the fishing chart.

It should be kept in mind that an obstruction may deteriorate or be removed after it is reported. Particular attention should be paid to type of gear and damage sustained because other gear may not be affected. Generally loran fixes were used to derive latitude and longitude readings. However, some slight inaccuracies may exist when loran fixes were not provided.

ACKNOWLEDGMENT

We extend our appreciation to Charles M. Roithmayr and Elmer J. Gutherz for reviewing this manuscript.

LITERATURE CITED

GRAHAM, G. L.
1975. Bottom fishing obstructions. Texas-Louisiana and Gulf. Texas A&M Univ. Sea Grant Publ. TAMU-SG-76-506.

APPENDIX TABLE

Codes to Gear and Damage

Gear	Abbreviation
Scallop trawl	PT
Lampara seine	LP
Purse seine	PS
Gill net	GN
Lift net	LN
Separator net	SN
Shrimp trawl	ST
Tumbler dredge	TD
Fish trawl	FT
Scallop dredge	SD
Midwater trawl	MT
Beam trawl	BT
Clam dredge	CD

Damage	Abbreviation
Torn webbing	T
Lost whole rig	L
Hang-up	Z
Gear fouled	F

NATIONAL MARINE FISHERIES SERVICE
SEFC,PASCAGOULA LAB

HANG DATA

SOUTHEASTERN NORTH AMERICA
2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	3651	7439	65	3H42286 3H52932	ST	T
1	3649	7441	50	3H42257 3H52934	ST	T
1	3645	7440	71	3H42220 3H52935	ST	T
1	3636	7443	80	3H42112 3H52923	ST	T
1	3623	7449	79	3H41940 3H52922	ST	T
1	3622	7448	135	3H41936 3H52918	FT	Z
1	3554	7452	51	3H41627 3L14817	ST	L
1	3550	7454	49	3H41576 3L14814	FT	T
1	3549	7453	50	3H41575 3L14810	ST	T
1	3546	7450	59	3H41568 3L14799	ST	T
1	3545	7448	280	3H51568 3L14794	ST	T
1	3544	7451	62	3H41537 3L14799	ST	T
1	3542	7451	65	3H41523 3L14793	ST	T
1	3541	7452	48	3H41506 3L14794	ST	L
1	3536	7451	70	3H41470 3L14782	TD	L
1	3522	7452	320	3H41354 3L14755	ST	F
1	3517	7500	85	3H41261 3L14758	FT	T
1	3515	7459	240	3H41255 3L14753	ST	T
1	3508	7508	45	3H41158 3L14754	ST	T
1	3507	7504	190	3H41185 3L14745	ST	L
1	3506	7509	100	3H41146 3L14752	ST	T
1	3506	7510	60	3H41140 3L14753	TD	Z
1	3505	7506	200	3H41168 3L14743	ST	T
1	3505	7509	120	3H41143 3L14750	ST	T
1	3457	7523	50	3L14760 3H61143	ST	T
1	3454	7523	101	3H41052 3L14750	ST	T
1	3454	7525	75	3L14757 3H61173	ST	T
1	3453	7530	38	3L14765 3H61195	FT	T
1	3452	7532	38	3L14765 3H61211	FT	T
1	3446	7537	50	3L14759 3H61295	ST	T
1	3445	7538	40	3L14758 3H61304	ST	T
1	3438	7548	34	3L14763 3H61425	FT	Z
1	3437	7538	103	3L14740 3H61378	ST	L
1	3437	7544	35	3L14754 3H61409	FT	T
1	3436	7545	38	3L14753 3H61425	FT	Z
1	3433	7546	50	3L14746 3H61459	ST	T
1	3433	7706	9	3L14926 3H62086	ST	T
1	3432	7651	11	3L14888 3H61970	FT	T
1	3431	7640	9	3L14860 3H61880	ST	T
1	3426	7542	215	3L14718 3H61498	ST	T
1	3425	7652	12	3L14876 3H62019	ST	T
1	3424	7544	215	3L14719 3H61523	ST	T
1	3418	7708	13	3L14999 3H62205	FT	T

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HANG DATA

SOUTHEASTERN NORTH AMERICA
2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	3416	7554	195	3L14717 3H61653	ST	T
1	3416	7726	11	3L14940 3H62375	FT	Z
1	3414	7637	18	3L14811 3H61975	ST	T
1	3407	7719	13	3L14898 3H62374	ST	T
1	3407	7722	13	3L14908 3H62401	FT	Z
1	3404	7615	50	3L14730 3H61896	ST	T
1	3357	7721	15	3L14877 3H62467	ST	T
1	3354	7808	5	3L15002 3H62981	CD	F
1	3352	7813	5	3L15009 3H62935	ST	T
1	3343	7623	220	3L14678 3H62114	ST	T
1	3341	7720	14	3L14830 3H62571	FT	T
1	3340	7721	15	3L14834 3H62575	FT	T
1	3339	7633	143	3L14690 3H62220	TD	F
1	3336	7657	54	3L14745 3H62420	SD	F
1	3335	7814	10	3L14973 3H63065	FT	T
1	3333	7641	150	3L14746 3H62319	ST	L
1	3329	7822	12	3L14979 3H63174	ST	T
1	3325	7640	220	3L14658 3H62368	ST	T
1	3324	7818	14	3L14951 3H63175	ST	T
1	3324	7820	13	3L14964 3H63198	ST	T
1	3321	7740	15	3L14820 3H62875	FT	Z
1	3321	7832	11	3L14993 3H63312	ST	T
1	3320	7740	14	3L12812 3H62877	FT	F
1	3305	7711	190	3L14659 3H62740	ST	T
1	3301	7849	12	3L14983 3H63595	ST	T
1	3255	7808	50	3L14805 3H63270	FT	T
1	3254	7727	175	3L14655 3H62927	ST	T
1	3254	7812	38	3L14813 3H63304	MT	T
1	3253	7833	20	3L14889 3H63500	ST	T
1	3250	7817	30	3L14811 3H63374	FT	T
1	3249	7838	18	3L14887 3H63565	ST	T
1	3248	7820	30	3L14812 3H63414	FT	L
1	3247	7823	30	3L14818 3H63445	FT	T
1	3239	7833	51	3L14809 3H63570	CD	T
1	3239	7836	27	3L14815 3H63587	SD	Z
1	3237	7951	6	3L15125 3H64260	ST	F
1	3235	7829	103	3L14770 3H63546	CD	T
1	3234	7921	14	3L14076 3H64014	ST	T
1	3232	7844	25	3L14805 3H63690	ST	T
1	3228	7849	45	3L14793 3H63744	ST	T
1	3227	7806	190	3L14632 3H63381	BT	T
1	3220	7812	190	3L14600 3H63459	ST	L
1	3219	7945	14	3L14900 3H64196	FT	T
1	3219	7946	15	3L14900 3H64200	ST	F

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SOUTHEASTERN NORTH AMERICA
2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	3216	7905	40	3L14765 3H63903	ST	T
1	3210	7834	233	3L14598 3H63669	TD	Z
1	3209	8021	8	3L14740 3H64279	ST	F
1	3204	8024	9	3L14673 3H64676	ST	F
1	3203	7926	30	3L14684 3H64063	FT	Z
1	3152	7822	320	3L14400 3H63605	ST	T
1	3146	8034	11	3L14442 3H64264	ST	T
1	3135	7938	50	3L14375 3H64087	ST	T
1	3131	7927	220	3L14308 3H64033	ST	T
1	3131	7946	29	3L14316 3H64115	FT	Z
1	3111	7955	30	3L14078 3H64120	ST	T
1	3110	7954	32	3L14072 3H64115	FT	Z
1	3106	7956	29	3L14004 3H64115	ST	T
1	3105	7956	30	3L13996 3H64113	ST	L
1	3058	7947	175	3L13900 3H64073	ST	T
1	3056	8110	9	3L13800 3H64251	FT	F
1	3049	8015	23	3L13782 3H64146	ST	T
1	3036	8013	24	3L13635 3H64124	TD	F
1	3031	8002	150	3L13579 3H64088	ST	T
1	3025	8026	23	3L13485 3H64142	ST	T
1	3023	8004	182	3L13474 3H64080	ST	Z
1	3017	8016	28	3L13395 3H64109	ST	T
1	3016	8012	25	3L13385 3H64094	ST	T
1	3010	8016	38	3L13308 3H64098	TD	Z
1	3008	8018	26	3L13281 3H64100	FT	T
1	3001	8010	180	3L13200 3H64074	ST	F
1	3001	8031	22	3L13191 3H64124	TD	F
1	3000	8008	189	3L13190 3H64068	ST	F
1	3000	8010	180	3L13188 3H64073	ST	T
1	2959	8009	210	3L13182 3H64068	ST	T
1	2958	8010	185	3L13173 3H64070	ST	L
1	2958	8011	160	3L13163 3H64071	ST	T
1	2957	8011	175	3L13150 3H64070	ST	F
1	2955	8010	200	3L13124 3H64063	ST	T
1	2955	8012	150	3L13125 3H64069	ST	T
1	2954	8011	185	3L13119 3H64068	ST	T
1	2954	8013	190	3L13115 3H64073	ST	T
1	2953	8005	250	3L13112 3H64050	ST	T
1	2953	8012	180	3L13100 3H64071	ST	T
1	2953	8013	180	3L13101 3H64072	ST	F
1	2953	8019	29	3L13100 3H64087	SD	Z
1	2952	8011	180	3L13091 3H64068	ST	F
1	2952	8012	180	3L13087 3H64070	ST	F
1	2952	8013	180	3L13085 3H64070	ST	T

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SOUTHEASTERN NORTH AMERICA
2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	2952	8017	29	3L13090 3H64081	FT	T
1	2952	8031	20	3L13085 3H64111	FT	T
1	2950	8007	200	3L13070 3H64052	ST	F
1	2950	8011	180	3L13073 3H64065	ST	T
1	2950	8012	200	3L13075 3H64061	ST	T
1	2949	8036	18	3L13045 3H64120	TD	Z
1	2948	8010	185	3L13045 3H64059	ST	F
1	2948	8012	162	3L13044 3H64063	ST	L
1	2947	8011	180	3L13025 3H64058	ST	F
1	2947	8013	195	3L13027 3H64062	ST	T
1	2946	8010	195	3L13011 3H64056	ST	T
1	2946	8011	185	3L13006 3H64057	ST	F
1	2945	8012	200	3L13000 3H64058	ST	L
1	2945	8028	18	3L12996 3H64096	FT	Z
1	2944	8010	177	3L12993 3H64053	ST	T
1	2944	8103	12	3L12978 3H64165	TD	F
1	2942	8010	180	3L12971 3H64050	ST	T
1	2940	8011	170	3L12941 3H64053	ST	L
1	2940	8017	40	3L12943 3H64069	ST	T
1	2939	8012	185	3L12925 3H64051	ST	F
1	2938	8016	50	3L12915 3H64061	ST	T
1	2937	8010	210	3L12900 3H64048	ST	T
1	2935	8011	100	3L12875 3H64045	ST	T
1	2931	8008	215	3L12835 3H64036	ST	F
1	2931	8009	185	3L12838 3H64039	ST	F
1	2930	8008	180	3L12820 3H64036	ST	T
1	2929	7953	375	3L12812 3H63993	ST	T
1	2928	8008	200	3L12797 3H64033	ST	L
1	2928	8009	200	3L12796 3H64035	ST	F
1	2925	8014	38	3L12760 3H64042	FT	T
1	2925	8015	35	3L12755 3H64045	TD	F
1	2924	8007	190	3L12751 3H64025	ST	T
1	2922	8006	200	3L12724 3H64019	ST	T
1	2922	8007	185	3L12723 3H64023	ST	F
1	2921	8039	16	3L12705 3H64097	TD	F
1	2920	7949	200	3L12700 3H63974	ST	T
1	2920	8014	35	3L12690 3H64037	SD	F
1	2920	8016	30	3L12698 3H64045	SD	F
1	2919	7959	245	3L12687 3H63697	ST	F
1	2919	8018	25	3L12686 3H64048	BT	T
1	2918	7959	260	3L12675 3H63996	ST	T
1	2917	8004	360	3L52294 3H63845	ST	T
1	2914	8002	238	3L12625 3H64001	ST	T
1	2913	8032	16	3L12607 3H64074	TD	F

NATIONAL MARINE FISHERIES SERVICE
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SOUTHEASTERN NORTH AMERICA
2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	2912	8002	203	3L12599 3H64000	ST	T
1	2912	8019	21	3L12598 3H64043	MT	F
1	2910	8005	80	3L12575 3H64009	SD	Z
1	2909	8000	205	3L51348 3H63990	ST	T
1	2909	8037	13	3L12560 3H64080	TD	F
1	2907	8001	195	3L12550 3H63998	ST	L
1	2907	8031	15	3L12543 3H64067	TD	F
1	2906	8017	25	3L12525 3H64033	TD	F
1	2905	8016	25	3L12510 3H64035	PT	L
1	2904	8013	32	3L12499 3H64023	FT	T
1	2902	8016	26	3L12476 3H64030	TD	F
1	2902	8038	12	3L12475 3H64076	TD	F
1	2902	8039	11	3L12477 3H64080	TD	F
1	2901	8031	13	3L12455 3H64059	TD	Z
1	2859	7957	222	3L12443 3H63976	ST	F
1	2858	8007	46	3L12429 3H64000	ST	T
1	2856	8003	100	3L13141 3H64045	ST	Z
1	2856	8016	22	3L12400 3H64023	SD	F
1	2854	8007	45	3L12378 3H63997	BT	T
1	2854	8036	12	3L12379 3H64065	TD	I
1	2853	7958	180	3L12370 3H63975	ST	T
1	2853	8014	20	3L12370 3H64026	SD	T
1	2852	7946	350	3L12365 3H63945	ST	T
1	2852	7954	200	3L12360 3H63963	ST	T
1	2852	8033	14	3L12352 3H64057	TD	F
1	2850	8004	80	3L12330 3H63988	BT	F
1	2849	8010	31	3L12317 3H64000	ST	Z
1	2848	8028	13	3L12300 3H64041	TD	F
1	2848	8028	13	3L12300 3H64041	TD	F
1	2843	8005	40	3L12248 3H63986	BT	T
1	2842	8008	31	3L12228 3H63986	ST	Z
1	2842	8012	27	3L12227 3H64000	TD	F
1	2835	8014	17	3L51223 3H63997	SD	F
1	2834	8007	30	3L51247 3H63981	ST	T
1	2833	8015	18	3L51212 3H63999	TD	F
1	2830	7951	182	3L51311 3H63938	ST	Z
1	2830	7952	200	3L51306 3H63940	ST	L
1	2827	8004	35	3L51242 3H63969	TD	Z
1	2826	7951	180	3L51303 3H63935	ST	T
1	2826	8010	26	3L51213 3H63982	FT	T
1	2825	8005	32	3L51236 3H63969	ST	T
1	2824	8014	20	3L51195 3H63990	TD	F
1	2823	8009	25	3L51212 3H63977	TD	F
1	2823	8017	15	3L12000 3H63996	SD	T

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2400 TO 3830 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	2823	8031	8	3L12000 3H64025	ST	T
1	2821	7951	180	3L51294 3H63935	ST	T
1	2821	8014	15	3L51189 3H63987	SD	Z
1	2819	8034	6	3L11968 3H64031	ST	T
1	2818	8034	6	3L11950 3H64028	ST	F
1	2816	8005	28	3L51212 3H63962	ST	T
1	2811	8010	22	3L51180 3H63971	TD	F
1	2809	8003	36	3L51205 3H63953	ST	T
1	2809	8010	19	3L51175 3H63969	SD	T
1	2809	8014	16	3L51160 3H63978	SD	L
1	2807	7940	305	3L51325 3H63896	TD	F
1	2803	8006	23	3L51178 3H63956	ST	F
1	2803	8014	16	3L51144 3H63974	TD	Z
1	2800	8006	23	3L51170 3H63954	TD	F
1	2759	7856	480	3L51635 3H63771	ST	Z
1	2759	8008	22	3L51159 3H63957	ST	T
1	2759	8012	15	3L51141 3H63966	MT	T
1	2757	8005	22	3L51168 3H63949	TD	T
1	2753	8005	22	3L51157 3H63946	SD	F
1	2753	8008	20	3L51143 3H63954	TD	F
1	2752	8003	26	3L51164 3H63941	ST	T
1	2751	8002	31	3L51164 3H63939	FT	T
1	2742	8003	23	3L51137 3H63935	SD	F
1	2740	7959	50	3L51151 3H63925	FT	T
1	2739	7959	41	3L51149 3H63924	FT	T
1	2738	8006	15	3L51111 3H63940	SD	Z
1	2737	8006	18	3L51109 3H63939	TD	F
1	2736	8006	14	3L51105 3H63938	SD	Z
1	2735	8005	18	3L51108 3H63935	FT	Z
1	2723	7907	10	3L51660 3H63789	ST	L
1	2721	7915	265	3L51490 3H63809	FT	T
1	2716	8002	26	3L51069 3H63918	FT	T
1	2712	7952	180	3L51142 3H63893	ST	F
1	2650	7944	200	3L51220 3H63874	ST	L
1	2631	8001	33	3L51309 3H63893	ST	T
1	2627	8001	13	3L51345 3H63891	ST	T
1	2547	7919	25	3L51960 3H63787	TD	Z
1	2545	7959	150	3L51697 3H63867	TD	F
1	2543	7920	120	3L51985 3H63787	TD	F
1	2535	8000	210	3L51771 3H63866	ST	L
1	2531	8000	225	3L51802 3H63864	ST	F
1	2531	8006	15	3L51769 3H63876	SD	T
1	2530	7919	368	3L52071 3H63785	ST	T
1	2522	7919	300	3L52151 3H63779	ST	L

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
1	2520	8000	240	3L51887 3H63860	ST	Z
1	2517	8010	25	3L51852 3H63877	ST	T
1	2516	8010	15	3L51859 3H63877	ST	T
1	2445	7918	300	3L52406 3H63780	ST	F

GULF OF MEXICO
2415 TO 3020 N.LAT. 8100 TO 9730 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
2	2431	8116	98	3L33583 3H13532	SD	Z
2	2415	8124	153	3L33557 3H13489	TD	F
2	2413	8141	250	3L33552 3H13461	ST	T
2	2618	8202	6	3H13667 3H01013	SN	T
2	2600	8203	7	3H01032 3H13627	ST	T
2	2545	8203	10	3H01046 3H13596	ST	T
2	2617	8203	8	3H01016 3H13662	ST	T
2	2609	8210	9	3H01034 3H13636	ST	T
2	2451	8212	14	3H01112 3H13475	ST	T
2	2416	8230	200	3H01178 3H13374	ST	T
2	2446	8230	15	3H01160 3H13429	ST	L
2	2648	8245	14	3H01130 3H13668	ST	T
2	2418	8254	200	3H01241 3H13326	ST	F
2	2450	8259	25	3H01246 3H13376	MT	T
2	2446	8259	25	3H01248 3H13368	ST	T
2	2722	8302	13	3H01428 3H13727	ST	T
2	2422	8305	40	3H01274 3H13308	ST	L
2	2450	8307	15	3H01271 3H13456	ST	T
2	2504	8308	30	3H01273 3H13382	ST	T
2	2717	8310	13	3H01465 3H13702	ST	T
2	2707	8319	23	3H01483 3H13657	ST	T
2	2425	8323	215	3H01332 3H13270	ST	T
2	2428	8329	220	3H01356 3H13260	ST	T
2	2429	8330	210	3H01357 3H13259	ST	T
2	2429	8331	220	3H01360 3H13258	ST	T
2	2433	8334	250	3H01372 3H13257	ST	T
2	2930	8335	5	3H02744 3H33473	ST	T
2	2928	8403	11	3H02948 3H33474	ST	T
2	2845	8407	16	3H02650 3H13877	ST	T
2	2925	8412	13	3H03000 3H33471	ST	T
2	2938	8415	11	3H03101 3H33492	ST	T
2	2455	8417	215	3H01573 3H33160	ST	L

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
2	2517	8425	230	3H01641 3H33190	ST	L
2	2946	8432	6	3H03282 3H13991	ST	T
2	2759	8510	230	3H02681 3H13505	FT	F
2	2914	8515	21	3H03400 3H13859	SD	F
2	2909	8517	18	3H03360 3H13799	SD	Z
2	2804	8527	240	3H02809 3H13439	FT	T
2	2747	8527	400	3H02675 3H13370	ST	F
2	2808	8546	330	3H02927 3H13340	FT	L
2	2807	8552	385	3H02942 3H13296	FT	F
2	2932	8604	40	3H03608 3H13524	FT	F
2	2836	8615	200	3H03232 3H13236	ST	T
2	2854	8626	200	3H03372 3H13198	ST	F
2	2907	8637	225	3H03455 3H13124	ST	T
2	2240	8637	206	3H01879 3H32569	ST	T
2	2915	8639	215	3H03498 3H13123	ST	L
2	2930	8640	150	3H03567 3H13136	ST	L
2	3000	8645	60	3H03656 3H13102	ST	L
2	3004	8645	45	3H03664 3H13101	ST	T
2	2848	8647	300	3H03347 3H12976	ST	F
2	3003	8648	57	3H03660 3H13072	ST	T
2	3004	8655	54	3H03656 3H13000	ST	L
2	3006	8656	36	3H03659 3H12989	ST	T
2	2950	8703	98	3H03616 3H12910	MT	T
2	3019	8707	4	3H03671 3H12875	FT	T
2	2911	8709	490	3H02659 3H12855	ST	T
2	2306	8711	150	3H02018 3H32578	ST	T
2	2845	8714	480	3H03341 3H12706	FT	T
2	2915	8717	450	3H03483 3H12723	ST	T
2	2939	8719	56	3H03572 3H12729	FT	T
2	2922	8724	220	3H03508 3H12655	ST	T
2	2958	8726	17	3H03618 3H12674	ST	T
2	2939	8727	33	3H03566 3H12647	GN	F
2	2921	8727	250	3H03503 3H12622	ST	T
2	2928	8728	55	3H03528 3H12620	FT	T
2	2926	8729	80	3H03522 3H12608	ST	L
2	2933	8730	38	3H03545 3H12607	ST	T
2	2358	8730	200	3H02173 3H32675	ST	T
2	2924	8731	100	3H03512 3H12581	ST	L
2	2929	8731	37	3H03531 3H12587	FT	Z
2	2921	8732	245	3H03501 3H12571	ST	T
2	2914	8735	500	3H03474 3H12526	ST	T
2	2935	8735	30	3H03547 3H12553	FT	Z
2	2926	8735	40	3H03518 3H12546	FT	Z
2	2920	8740	100	3H03494 3H12480	FT	T

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A		GEAR	DAMAGE
2	2939	8740	20	3H03556	3H12507	FT	F
2	2917	8742	208	3H03482	3H12456	ST	F
2	2923	8744	50	3H03503	3H12442	ST	L
2	2912	8746	425	3H03462	3H12427	FT	F
2	2923	8748	45	3H03502	3H12399	ST	T
2	2855	8749	900	3H03393	3H12359	ST	T
2	2915	8750	200	3H03472	3H12370	FT	F
2	2915	8751	190	3H03471	3H12360	ST	T
2	2941	8755	22	3H03554	3H12349	FT	T
2	2938	8755	22	3H03546	3H12347	MT	F
2	2912	8756	243	3H03459	3H12301	ST	F
2	2913	8757	225	3H03461	3H12290	FT	T
2	2925	8759	35	3H03503	3H12277	FT	T
2	2923	8800	43	3H03496	3H12269	ST	T
2	2911	8801	225	3H03455	3H12249	ST	T
2	2912	8802	225	3H03453	3H12239	FT	T
2	2910	8802	270	3H03451	3H12236	ST	T
2	2912	8803	225	3H03456	3H12227	ST	T
2	2912	8805	195	3H12202	3H03457	ST	T
2	2910	8805	250	3H12204	3H03449	ST	L
2	2954	8806	17	3H12251	3H03581	MT	F
2	2929	8806	45	3H12212	3H03513	ST	T
2	2911	8807	200	3H12181	3H03453	FT	T
2	3014	8808	4	3H12268	3H03622	LN	T
2	3013	8808	7	3H12265	3H03620	FT	L
2	2919	8808	50	3H12170	3H03478	ST	T
2	2902	8808	500	3H12164	3H03420	FT	F
2	2900	8808	712	3H12162	3H03412	ST	T
2	2856	8808	838	3H12162	3H03396	ST	Z
2	3014	8809	5	3H12255	3H03621	MT	Z
2	2910	8810	205	3H12150	3H03449	ST	F
2	2921	8811	46	3H12150	3H03486	ST	T
2	2911	8811	200	3H12140	3H03452	ST	L
2	2906	8811	290	3H12135	3H03434	ST	T
2	3012	8812	7	3H12222	3H03615	MT	F
2	2912	8812	130	3H12130	3H03454	FT	F
2	2914	8813	68	3H12120	3H03461	ST	T
2	2910	8813	200	3H12118	3H03447	FT	F
2	2912	8814	120	3H12110	3H03455	ST	L
2	2909	8814	225	3H12105	3H03443	ST	F
2	2917	8816	46	3H12090	3H03467	FT	T
2	2915	8816	50	3H12090	3H03465	FT	T
2	2843	8817	825	3H12064	3H03348	ST	L
2	2915	8818	50	3H12070	3H03463	ST	F

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
2	2912	8818	100	3H12065 3H03454	ST	L
2	2909	8818	200	3H12063 3H03442	ST	L
2	2907	8818	250	3H12065 3H03436	ST	F
2	2906	8819	260	3H12050 3H03431	ST	T
2	2954	8820	20	3H12109 3H03573	ST	T
2	3009	8821	7	3H12126 3H03605	ST	T
2	3007	8821	10	3H12125 3H03601	GN	F
2	3014	8822	3	3H12130 3H03613	MT	T
2	2957	8823	18	3H12080 3H03578	ST	F
2	2918	8823	36	3H12015 3H03472	ST	T
2	2905	8823	215	3H12007 3H03428	ST	L
2	2900	8824	400	3H11995 3H03411	LP	T
2	2915	8825	60	3H11995 3H03461	ST	T
2	3015	8825	3	3H12102 3H03613	MT	T
2	2947	8825	19	3H12040 3H03553	FT	T
2	2943	8825	21	3H12030 3H03543	MT	T
2	2850	8826	600	3H11972 3H03375	FT	T
2	2905	8827	215	3H11965 3H03427	ST	T
2	2859	8827	400	3H11963 3H03406	ST	L
2	2917	8828	38	3H11967 3H03468	ST	T
2	2905	8828	200	3H11951 3H03428	ST	F
2	3013	8830	3	3H12050 3H03607	LN	T
2	2939	8830	22	3H11975 3H03530	ST	T
2	2937	8831	20	3H11959 3H03525	ST	T
2	2926	8831	30	3H11940 3H03494	ST	T
2	2957	8833	14	3H11982 3H03572	GN	T
2	2919	8833	35	3H11910 3H03472	MT	T
2	2909	8833	110	3H11904 3H03440	ST	T
2	2932	8834	22	3H11916 3H03509	MT	T
2	2919	8834	35	3H11900 3H03471	MT	T
2	2903	8834	220	3H11890 3H03418	ST	T
2	2912	8835	32	3H11885 3H03449	FT	T
2	2901	8835	205	3H11875 3H03411	ST	F
2	2913	8836	40	3H11874 3H03452	MT	F
2	2901	8836	200	3H11870 3H03412	ST	F
2	2930	8837	20	3H11880 3H03502	ST	T
2	2924	8837	29	3H11875 3H03486	MT	T
2	2208	8838	20	3H02132 3H32327	ST	T
2	3017	8840	3	3H11970 3H03609	MT	T
2	2917	8840	35	3H11833 3H03463	ST	L
2	2857	8840	230	3H11825 3H03398	ST	T
2	2911	8841	41	3H11830 3H03445	ST	T
2	2851	8841	405	3H11820 3H03378	ST	F
2	2919	8842	32	3H11818 3H03468	FT	L

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
2	2906	8843	54	3H11798 3H03428	ST	T
2	2229	8843	28	3H02178 3H32365	MT	T
2	2922	8844	27	3H11799 3H03477	ST	Z
2	2926	8845	15	3H03488 3H11787	MT	L
2	2912	8845	38	3H11778 3H03448	FT	Z
2	2853	8845	270	3H11775 3H03386	ST	F
2	3004	8846	8	3H03581 3H11873	MT	T
2	2854	8846	220	3H03389 3H11766	ST	T
2	2232	8847	29	3H02195 3H32369	ST	T
2	2928	8848	9	3H03492 3H11765	MT	L
2	2916	8848	34	3H03458 3H11747	ST	T
2	2910	8849	48	3H03440 3H11730	FT	T
2	2914	8850	38	3H03451 3H11725	SN	T
2	2910	8850	40	3H03439 3H11724	ST	L
2	2915	8851	32	3H03454 3H11719	FT	T
2	2902	8852	74	3H03414 3H11700	ST	T
2	2913	8852	36	3H03448 3H11702	ST	T
2	3002	8854	4	3H03572 3H11790	LN	T
2	2921	8857	17	3H03471 3H11660	MT	T
2	2852	8857	160	3H03381 3H11653	FT	F
2	2850	8858	185	3H03375 3H11645	ST	F
2	2835	8912	180	3H03337 3H11536	ST	L
2	2858	8912	14	3H03400 3H11494	ST	L
2	2843	8918	80	3H03354 3H11467	ST	T
2	2849	8933	45	3H21067 3H33458	ST	L
2	2846	8934	48	3H21082 3H33449	ST	F
2	2859	8934	30	3H21032 3H33488	ST	L
2	2327	8934	124	3H02400 3H32413	ST	T
2	2841	8935	58	3H21105 3H33435	ST	T
2	2300	8936	76	3H02348 3H32342	ST	F
2	2851	8937	40	3H21068 3H33465	ST	T
2	2843	8939	50	3H21106 3H33443	ST	L
2	2844	8942	47	3H21114 3H33445	FT	T
2	2849	8943	30	3H21091 3H33461	ST	T
2	2856	8954	20	3H21098 3H33486	FT	T
2	2227	8959	37	3H02330 3H32225	ST	T
2	2829	9000	60	3H21270 3H33402	ST	L
2	2832	9004	39	3H21277 3H33412	FT	T
2	2819	9006	50	3H21348 3H33368	FT	T
2	2834	9010	32	3H21304 3H33420	ST	T
2	2827	9015	30	3H21370 3H33396	ST	T
2	2222	9015	30	3H22127 3H32183	FT	T
2	2821	9029	30	3H21498 3H33377	ST	T
2	2814	9041	40	3H21619 3H33351	FT	T

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A		GEAR	DAMAGE
2	2811	9051	45	3H21710	3H33340	FT	T
2	2815	9055	52	3H21734	3H33356	FT	Z
2	2834	9059	16	3H21723	3H33433	FT	T
2	2753	9105	225	3H21875	3H33261	ST	T
2	2806	9106	58	3H21853	3H33318	ST	L
2	2815	9111	40	3H21875	3H33355	TD	Z
2	2810	9113	50	3H21905	3H33335	ST	L
2	2213	9114	52	3H22318	3H32029	FT	Z
2	2806	9119	64	3H21966	3H33317	TD	L
2	2217	9129	55	3H22358	3H32007	FT	Z
2	2833	9131	22	3H22038	3H33437	SN	T
2	2815	9135	34	3H22099	3H33356	ST	T
2	2822	9135	34	3H22090	3H33387	ST	T
2	2832	9138	22	3H22108	3H32435	SN	T
2	1948	9142	23	3H22430	3H31756	FT	Z
2	2739	9145	500	3H22232	3H33177	ST	T
2	2818	9146	35	3H22199	3H33372	FT	T
2	2736	9146	400	3H22243	3H33161	ST	T
2	2825	9146	30	3H22194	3H33404	SN	T
2	1951	9147	27	3H22445	3H31747	FT	Z
2	1956	9147	27	3H22440	3H31752	FT	Z
2	1942	9149	27	3H22448	3H31732	FT	T
2	2812	9151	46	3H22254	3H33341	FT	T
2	2002	9151	27	3H22450	3H31744	FT	T
2	2005	9151	27	3H22447	3H31753	FT	Z
2	1945	9151	27	3H22455	3H31735	FT	Z
2	2001	9152	26	3H22452	3H31748	FT	T
2	2003	9152	26	3H22452	3H31750	FT	T
2	2003	9153	26	3H22455	3H31748	FT	T
2	2023	9153	18	3H22452	3H31770	ST	T
2	2818	9154	36	3H22280	3H33372	ST	F
2	2002	9154	28	3H22457	3H31745	FT	T
2	2900	9155	9	3H22273	3H33562	ST	F
2	2003	9155	24	3H22459	3H31744	FT	T
2	1949	9157	45	3H22470	3H31725	FT	T
2	2002	9157	30	3H22469	3H31739	FT	Z
2	2811	9158	40	3H22323	3H33336	FT	T
2	2004	9158	30	3H22473	3H31748	TR	L
2	2003	9200	32	3H22475	3H31732	TR	L
2	2837	9201	22	3H22336	3H33466	ST	F
2	2810	9209	40	3H22431	3H33330	FT	T
2	2742	9217	238	3H22504	3H33170	ST	T
2	2811	9220	35	3H22534	3H33335	ST	T
2	2811	9227	40	3H22595	3H33332	ST	L

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A		GEAR	DAMAGE
2	1935	9231	100	3H22552	3H31641	ST	L
2	2755	9233	110	3H22650	3H33235	ST	F
2	2810	9235	52	3H22677	3H33326	FT	T
2	2801	9235	50	3H22670	3H33270	TD	L
2	2809	9240	40	3H22725	3H35316	ST	T
2	2830	9241	28	3H22745	3H33441	FT	Z
2	2843	9251	17	3H22861	3H33519	FT	T
2	2753	9300	100	3H22890	3H33200	FT	T
2	2737	9303	200	3H22892	3H33087	ST	L
2	2925	9307	8	3H23050	3H33736	FT	T
2	2735	9313	210	3H22970	3H33056	SN	F
2	2737	9314	170	3H22985	3H33068	FT	T
2	2805	9315	51	3H23040	3H33270	ST	T
2	2825	9322	40	3H23146	3H33411	ST	T
2	2729	9322	315	3H23030	3H32995	ST	F
2	2806	9324	44	3H23124	3H33271	FT	T
2	1842	9327	33	3H22678	3H31498	PT	Z
2	2734	9330	200	3H23101	3H33015	ST	T
2	2733	9335	300	3H23138	3H32995	ST	F
2	2738	9337	200	3H23165	3H33031	ST	T
2	2738	9341	250	3H23195	3H33024	ST	T
2	2758	9343	55	3H23263	3H33182	ST	T
2	1932	9346	600	3H22734	3H31492	PT	Z
2	2820	9352	31	3H23404	3H33357	ST	T
2	2820	9355	30	3H23432	3H33352	ST	T
2	2803	9409	38	3H23480	3H33172	ST	T
2	2810	9417	27	3H23562	3H33221	FT	T
2	1856	9426	395	3H22814	3H31400	ST	Z
2	2803	9433	33	3H23639	3H33102	ST	T
2	2808	9435	31	3H23670	3H33150	FT	Z
2	2809	9436	30	3H23681	3H33151	FT	Z
2	2800	9438	40	3H23653	3H33055	ST	L
2	2757	9438	50	3H23643	3H33022	ST	T
2	2748	9445	200	3H23643	3H32906	ST	L
2	2745	9448	230	3H23664	3H32861	FT	Z
2	2745	9448	230	3H23664	3H32861	FT	Z
2	2828	9450	23	3H23844	3H33300	FT	Z
2	2804	9451	35	3H23736	3H33040	FT	Z
2	2757	9454	50	3H23720	3H32955	ST	T
2	2805	9505	38	3H23803	3H32983	ST	T
2	1846	9511	39	3H22909	3H31323	ST	Z
2	2805	9518	30	3H23849	3H32912	ST	T
2	2749	9521	60	3H23796	3H32730	FT	T
2	2751	9530	43	3H23831	3H32730	FT	F

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REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
2	2742	9543	70	3H23836 3H32536	ST	T
2	2804	9552	22	3H23932 3H32705	ST	L
2	2744	9610	42	3H23902 3H32389	ST	T
2	2720	9612	113	3H23834 3H32133	ST	T
2	2745	9613	40	3H23911 3H32380	FT	Z
2	2738	9613	45	3H23891 3H32311	FT	T
2	2710	9617	175	3H23816 3H32002	ST	L
2	2720	9620	85	3H23851 3H32080	ST	L
2	2732	9621	55	3H23887 3H32200	ST	T
2	2610	9622	55	3H23663 3H31428	ST	L
2	2632	9628	56	3H23726 3H31560	ST	L
2	2627	9630	40	3H23725 3H31495	ST	T
2	2030	9630	205	3H23150 3H31199	ST	T
2	2750	9633	20	3H23956 3H32318	FT	T
2	2649	9638	51	3H23801 3H31655	ST	T
2	2628	9642	25	3H23755 3H31414	FT	T
2	2730	9645	29	3H23921 3H32048	FT	T
2	2131	9646	700	3H23246 3H31169	ST	Z
2	2133	9648	600	3H23249 3H31167	ST	Z
2	2621	9658	19	3H23770 3H31243	ST	T
2	2602	9706	10	3H23741 3H03149	FT	T
2	2315	9716	370	3H23446 3H31090	ST	Z
2	2410	9727	25	3H23557 3H31047	FT	Z
2	2255	9736	23	3H23458 3H31068	ST	T

WEST INDIES
APPROX.1000 TO 2400 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
3	1302	5934	137		ST	T
3	1304	5941	130		TD	Z
3	1305	5943	290		ST	T
3	1028	6004	355		ST	F
3	1103	6050	37		ST	T
3	1353	6050	215		ST	Z
3	1111	6054	36		ST	Z
3	1112	6054	41		ST	T
3	1109	6054	34		ST	Z
3	1339	6055	155		TD	Z
3	2002	6854	30		TD	T
3	2000	6856	14		TD	Z
3	2015	6943	13		TD	Z

WEST INDIES

APPROX.1000 TO 2400 N.LAT. 5930 TO 8100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
3	2048	7131	355		ST	L
3	2052	7320	180		ST	T
3	2057	7341	17		ST	L
3	2044	7343	500		ST	F
3	2336	7525		3L33543 3L54820		
3	2351	7659	750		TD	F
3	2411	7713	150		TD	Z
3	2330	7933	5		ST	T
3	2325	7940	250		ST	L
3	2400	8027	12		ST	T

CARIBBEAN SEA

APPROX 1000 TO 2200 N.LAT. 6100 TO 8900 W.LONG

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
4	1404	6102	36		TD	Z
4	1536	6109	364		ST	Z
4	1536	6113	332		ST	Z
4	1522	6126	110		TD	Z
4	1534	6129	48		TD	Z
4	1535	6130	160		TD	Z
4	1210	6144	98		TD	Z
4	1212	6145	100		TD	L
4	1206	6145	12		TD	Z
4	1207	6145	40		TD	Z
4	1201	6154	230		ST	Z
4	1104	6205	59		TD	Z
4	1127	6217	68		ST	T
4	1133	6230	200		ST	T
4	1708	6238	18		ST	T
4	1704	6239	143		ST	Z
4	1707	6239	55		TD	Z
4	1716	6244	40		TD	Z
4	1733	6246	365		ST	L
4	1144	6247	390		ST	L
4	1104	6248	25		ST	T
4	1720	6252	305		ST	T
4	1737	6300	360		ST	L
4	1338	6301	392		ST	F
4	1134	6302	175		ST	L
4	1140	6305	245		ST	T
4	1810	6313	31		TD	Z

NATIONAL MARINE FISHERIES SERVICE
SEFC,PASCAGOULA LAB

HANG DATA

CARIBBEAN SEA
APPROX 1000 TO 2200 N.LAT. 6100 TO 8900 W.LONG

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
4	1807	6320	360		ST	L
4	1828	6322	363		ST	L
4	1737	6328	228		ST	T
4	1529	6337	6		TD	Z
4	1530	6338	200		ST	T
4	1807	6338	360		ST	L
4	1740	6346	405		ST	T
4	1114	6413	30		ST	Z
4	1846	6441	26		ST	T
4	1836	6446	28		ST	T
4	1836	6447	25		ST	T
4	1836	6448	28		ST	T
4	1838	6457	220		ST	T
4	1815	6458	23		ST	T
4	1807	6519	205		ST	T
4	1039	6520	700		ST	F
4	1044	6527	700		ST	F
4	1827	6535	40		ST	T
4	1026	6543	50		ST	T
4	1830	6555	150		ST	T
4	1751	6609	20		ST	T
4	1832	6647	200		ST	T
4	1051	6658	53		TD	Z
4	1054	6700	175		ST	Z
4	1056	6702	230		ST	Z
4	1826	6714	250		ST	T
4	1817	6717	250		ST	T
4	1806	6724	13		ST	L
4	1046	6803	40		TD	Z
4	1120	6816	240		ST	T
4	1958	6854	12	3L23155 3L31015	TD	Z
4	1153	6928	190		ST	T
4	1235	6956	280		ST	T
4	1229	7004	108		FT	Z
4	1227	7006	40		FT	Z
4	1150	7040	32		ST	T
4	1139	7124	15		ST	L
4	1231	7158	205		ST	Z
4	1202	7228	33		ST	T
4	1200	7230	20		FT	T
4	1221	7231	210		ST	L
4	1219	7234	195		FT	T
4	1124	7332	35		ST	Z
4	1104	7423	10		ST	T

NATIONAL MARINE FISHERIES SERVICE
SEFC,PASCAGOULA LAB

HANG DATA

CARIBBEAN SEA
APPROX 1000 TO 2200 N.LAT. 6100 TO 8900 W.LONG

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
4	1105	7428	13		ST	T
4	1109	7428	200		ST	F
4	1119	7453	580		ST	T
4	1112	7456	235		ST	L
4	1114	7521	720		ST	T
4	1107	7530	600		ST	T
4	1005	7553	50		TD	Z
4	0959	7553	60		ST	T
4	0951	7557	45		ST	F
4	1004	7606	110		TD	Z
4	0912	7621	24		ST	T
4	0936	7622	280		ST	T
4	0958	7629	695		ST	Z
4	0932	7638	800		ST	Z
4	0855	7656	360		FT	T
4	1736	7705	16		ST	T
4	1826	7706	200		TD	Z
4	0938	7857	65		TD	Z
4	0819	7948	20		ST	T
4	0825	7956	5		ST	T
4	0826	7956	8		ST	T
4	0827	7956	8		ST	T
4	1416	8026	50		TD	Z
4	1414	8029	195		TD	Z
4	1530	8104	16		ST	T
4	1454	8110	280		SD	Z
4	1515	8115	110		ST	T
4	1434	8131	240		FT	T
4	1650	8133	170		ST	L
4	1707	8138	400		ST	L
4	1412	8142	400		ST	F
4	1643	8153	140		FT	F
4	1322	8204	300		ST	Z
4	1241	8219	74		FT	Z
4	1302	8220	80		FT	L
4	1236	8221	76		ST	Z
4	1250	8222	66		ST	T
4	1219	8222	320		ST	T
4	1246	8223	70		FT	Z
4	1233	8228	85		FT	U
4	1217	8249	20		ST	T
4	1134	8307	125		ST	T
4	1623	8320	55		ST	T
4	1622	8331	167		ST	L

NATIONAL MARINE FISHERIES SERVICE
SEFC,PASCAGOULA LAB

HANG DATA

CARIBBEAN SEA
APPROX 1000 TO 2200 N.LAT. 6100 TO 8900 W.LONG

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
4	1626	8331	510		ST	F
4	1616	8359	350		ST	T
4	1612	8414	350		ST	F
4	1612	8424	325		ST	F

NE COAST OF SOUTH AMERICA
0015 TO 1000 N.LAT. 3500 TO 6100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
5	0945	6047	21		ST	T
5	0942	5953	120		ST	T
5	0940	5940	200		ST	T
5	0928	6004	44		ST	T
5	0924	5941	110		ST	T
5	0917	5919	250		ST	T
5	0916	5915	275		ST	T
5	0903	5900	75		ST	T
5	0806	5741	202		FT	T
5	0751	5442	450		ST	F
5	0748	5328	500		ST	L
5	0744	5652	200		ST	T
5	0741	5348	370		ST	T
5	0738	5411	75		ST	T
5	0732	5412	100		ST	T
5	0728	5435	118		ST	T
5	0728	5443	93		ST	T
5	0728	5511	75		TD	T
5	0727	5347	123		ST	T
5	0725	5435	78		ST	T
5	0718	5707	31		ST	T
5	0712	5647	27		ST	T
5	0709	5247	380		ST	Z
5	0702	5623	35		ST	T
5	0655	5401	31		ST	L
5	0651	5341	32		ST	T
5	0650	5534	28		ST	T
5	0648	5512	25		ST	F
5	0637	5503	22		ST	F
5	0637	5558	20		ST	L
5	0631	5347	24		ST	L
5	0624	5445	17		ST	T
5	0624	5500	16		FT	T

NATIONAL MARINE FISHERIES SERVICE
SEFC,PASCAGOULA LAB

HANG DATA

NE COAST OF SOUTH AMERICA
0015 TO 1000 N.LAT. 3500 TO 6100 W.LONG.

REGION	LATITUDE	LONGITUDE	DEPTH(FMS)	LORAN A	GEAR	DAMAGE
5	0623	5605	17		FT	T
5	0614	5231	38		ST	F
5	0610	5238	35		ST	F
5	0608	5237	30		ST	Z
5	0556	5203	39		ST	T
5	0556	5220	31		ST	T
5	0546	5202	38		ST	T
5	0543	5115	100		ST	F
5	0541	5206	35		ST	T
5	0538	5252	22		ST	T
5	0420	5037	38		ST	T
5	0311	3840	25		ST	T
5	0307	3841	140		TD	L
5	0304	3858	30		ST	T
5	0241	4748	180		ST	T
5	0239	3908	60		ST	L
5	0232	4917	11		ST	F
5	0231	4051	15		ST	T
5	0230	4750	65		ST	T
5	0228	3928	24		ST	T
5	0217	3937	30		ST	T
5	0150	4731	45		ST	T
5	0145	4646	275		ST	T
5	0137	4645	64		ST	T
5	0023	4705	21		ST	T
5	0017	4427	60		ST	T

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672. Seasonal occurrence of young Guld menhaden and other fishes in a northwestern Florida estuary. By Marlin E. Tagatz and E. Peter H. Wilkins. August 1973, iii + 14 p., 1 fig., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

673. Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. By Frank W. Steimle, Jr. and Richard B. Stone. December 1973, iii + 50 p., 2 figs., 5 app. tables.

674. Lake Erie bottom trawl explorations, 1962-66. By Edgar W. Bowman. January 1974, iv + 21 p., 9 figs., 1 table, 7 app. tables.

675. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 1. Report of the Symposium. March 1975, iii + 33 p.; Part 2. Review and contributed papers. July 1974, iv + 355 p. (38 papers); Part 3. Species synopses. June 1975, iii + 159 p. (8 papers). Richard S. Shomura and Francis Williams (editors). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

676. Price spreads and cost analyses for finfish and shellfish products at different marketing levels. By Erwin S. Penn. March 1974, vi + 74 p., 15 figs., 12 tables, 12 app. figs., 14 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

677. Abundance of benthic macroinvertebrates in natural and altered estuarine areas. By Gill Gilmore and Lee Trent. April 1974, iii + 13 p., 11 figs., 3 tables, 2 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

678. Distribution, abundance, and growth of juvenile sockeye salmon, *Oncorhynchus nerka*, and associated species in the Naknek River system, 1961-64. By Robert J. Ellis. September 1974, v + 53 p., 27 figs., 26 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

679. Kinds and abundance of zooplankton collected by the USCG icebreaker *Glacier* in the eastern Chukchi Sea, September-October 1970. By Bruce L. Wing. August 1974, iv + 18 p., 14 figs., 6 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

680. Pelagic amphipod crustaceans from the southeastern Bering Sea, June 1971. By Gerald A. Sanger. July 1974, iii + 8 p., 3 figs., 3 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

681. Physiological response of the cunner, *Tautogolabrus adspersus*, to cadmium. October 1974, iv + 33 p., 6 papers, various authors. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

682. Heat exchange between ocean and atmosphere in the eastern North Pacific for 1961-71. By N. E. Clark, L. Eber, R. M. Laurs, J. A. Renner, and J. F. T. Saur. December 1974, iii + 108 p., 2 figs., 1 table, 5 plates.

683. Bioeconomic relationships for the Maine lobster fishery with consideration of alternative management schemes. By Robert L. Dow, Frederick W. Bell, and Donald M. Harriman. March 1975, v + 44 p., 20 figs., 25 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

684. Age and size composition of the Atlantic menhaden, *Brevoortia tyrannus*, purse seine catch, 1963-71, with a brief discussion of the fishery. By William R. Nicholson. June 1975, iv + 28 p., 1 fig., 12 tables, 18 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

685. An annotated list of larval and juvenile fishes captured with surface-towed meter net in the South Atlantic Bight during four RV *Dolphin* cruises between May 1967 and February 1968. By Michael P. Fahay. March 1975, iv + 39 p., 19 figs., 9 tables, 1 app. table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

686. Pink salmon, *Oncorhunchus gorbuscha*, tagging experiments in southeastern Alaska, 1938-42 and 1945. By Roy E. Nakatani, Gerald J. Paulik, and Richard Van Cleve. April 1975, iv + 39 p., 24 figs., 16 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

687. Annotated bibliography on the biology of the menhadens, Genus *Brevoortia*, 1963-1973. By John W. Reintjes and Peggy M. Keney. April 1975, 92 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

688. Effect of gas supersaturated Columbia River water on the survival of juvenile chinook and coho salmon. By Theodore H. Blahm, Robert J. McConnell, and George R. Snyder. April 1975, iii + 22 p., 8 figs., 5 tables, 4 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

689. Ocean distribution of stocks of Pacific salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdnerii*, as shown by tagging experiments. Charts of tag recoveries by Canada, Japan, and the United States, 1956-69. By Robert R. French, Richard G. Bakkala, and Doyle F. Sutherland. June 1975, viii + 89 p., 117 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

690. Migratory routes of adult sockeye salmon, *Oncorhynchus nerka*, in the eastern Bering Sea and Bristol Bay. By Richard R. Straty. April 1975, iv + 32 p., 22 figs., 3 tables, 3 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

691. Seasonal distributions of larval flatfishes (Pleuronectiformes) on the continental shelf between Cape Cod, Massachusetts, and Cape Lookout, North Carolina, 1965-66. By W. G. Smith, J. D. Sibunka, and A. Wells. June 1975, iv + 68 p., 72 figs., 16 tables.

692. Expendable bathythermograph observations from the NMFS/MARAD Ship of Opportunity Program for 1972. By Steven K. Cook. June 1975, iv + 81 p., 81 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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694. Semiclosed seawater system with automatic salinity, temperature and turbidity control. By Sid Korn. September 1975, iii + 5 p., 7 figs., 1 table.

695. Distribution, relative abundance, and movement of skipjack tuna, *Katsuwonus pelamis*, in the Pacific Ocean based on Japanese tuna longline catches, 1964-67. By Walter M. Matsumoto. October 1975, iii + 30 p., 15 figs., 4 tables.

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697. Fish and hydrographic collections made by the research vessels *Dolphin* and *Delaware II* during 1968-72 from New York to Florida. By S. J. Wilk and M. J. Silverman. January 1976, iii + 159 p., 1 table, 2 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

698. Summer benthic fish fauna of Sandy Hook Bay, New Jersey. By Stuart J. Wilk and Myron J. Silverman. January 1976, iv + 16 p., 21 figs., 1 table, 2 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

699. Seasonal surface currents off the coasts of Vancouver Island and Washington as shown by drift bottle experiments, 1964-65. By W. James Ingraham, Jr. and James R. Hastings. May 1976, iii + 9 p., 4 figs., 4 tables.

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NOAA Technical Report NMFS SSRF-716

Fishes and Associated Environmental Data Collected in New York Bight, June 1974-June 1975

Stuart J. Wilk, Wallace W. Morse,
Daniel E. Ralph, and Thomas R. Azarovitz

September 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA TECHNICAL REPORTS

National Marine Fisheries Service, Special Scientific Report—Fisheries

The major responsibilities of the National Marine Fisheries Service (NMFS) are to monitor and assess the abundance and geographic distribution of fishery resources, to understand and predict fluctuations in the quantity and distribution of these resources, and to establish levels for optimum use of the resources. NMFS is also charged with the development and implementation of policies for managing national fishing grounds, development and enforcement of domestic fisheries regulations, surveillance of foreign fishing off United States coastal waters, and the development and enforcement of international fishery agreements and policies. NMFS also assists the fishing industry through marketing service and economic analysis programs, and mortgage insurance and vessel construction subsidies. It collects, analyzes, and publishes statistics on various phases of the industry.

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654. An electric detector system for recovering internally tagged menhaden, genus *Brevoortia*. By R. O. Parker, Jr. February 1972, iii + 7 p., 3 figs., 1 app. table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

655. Immobilization of fingerling salmon and trout by decompression. By Doyle F. Sutherland. March 1972, iii + 7 p., 3 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

656. The calico scallop, *Argopecten gibbus*. By Donald M. Allen and T. J. Costello. May 1972, iii + 19 p., 9 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

657. Making fish protein concentrates by enzymatic hydrolysis. A status report on research and some processes and products studied by NMFS. By Malcolm B. Hale. November 1972, v + 32 p., 15 figs., 17 tables, 1 app. table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

658. List of fishes of Alaska and adjacent waters with a guide to some of their literature. By Jay C. Quast and Elizabeth L. Hall. July 1972, iv + 47 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

659. The Southeast Fisheries Center bionumeric code. Part I: Fishes. By Harvey R. Bullis, Jr., Richard B. Roe, and Judith C. Gatlin. July 1972, xl + 95 p., 2 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

660. A freshwater fish electro-motivator (FFEM)-its characteristics and operation. By James E. Ellis and Charles C. Hoopes. November 1972, iii + 11 p., 2 figs.

661. A review of the literature on the development of skipjack tuna fisheries in the central and western Pacific Ocean. By Frank J. Hester and Tamio Otsu. January 1973, iii + 13 p., 1 fig. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

662. Seasonal distribution of tunas and billfishes in the Atlantic. By John P. Wise and Charles W. Davis. January 1973, iv + 24 p., 13 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

663. Fish larvae collected from the northeastern Pacific Ocean and Puget Sound during April and May 1967. By Kenneth D. Waldron. December 1972, iii + 16 p., 2 figs., 1 table, 4 app. tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

664. Tagging and tag-recovery experiments with Atlantic menhaden, *Brevoortia tyrannus*. By Richard L. Kroger and Robert L. Dryfoos. December 1972, iv + 11 p., 4 figs., 12 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

665. Larval fish survey of Humbolt Bay, California. By Maxwell B. Eldrige and Charles F. Bryan. December 1972, iii + 8 p., 8 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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669. Subpoint prediction for direct readout meterological satellites. By L. E. Eber. August 1973, iii + 7 p., 2 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

670. Unharvested fishes in the U.S. commercial fishery of western Lake Erie in 1969. By Harry D. Van Meter. July 1973, iii + 11 p., 6 figs., 6 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

671. Coastal upwelling indices, west coast of North America, 1946-71. By Andrew Bakun. June 1973, iv + 103 p., 6 figs., 3 tables, 45 app. figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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NOAA Technical Report NMFS SSRF-716

Fishes and Associated Environmental Data Collected in New York Bight, June 1974-June 1975

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September 1977

U.S. DEPARTMENT OF COMMERCE
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Fishes and Associated Environmental Data Collected in New York Bight, June 1974-June 1975

STUART J. WILK, WALLACE W. MORSE, DANIEL E. RALPH, and THOMAS R. AZAROVITZ[1]

ABSTRACT

Tabulations of fishes and associated environmental observations are given for 700 trawl stations made during 30 collecting intervals in the New York Bight from June 1974 to June 1975. Summary tables included give the following information: collecting interval data (vessel, dates, stations sampled, gear, and area); station data (date, location, time of day, total catch, and environmental observations); and catch data for 127 species, representing 67 families (location, number, and weight).

The 10 most frequently collected species were: *Merluccius bilinearis* (456 stations), *Scophthalmus aquosus* (419), *Raja erinacea* (411), *Urophycis chuss* (409), *Pseudopleuronectes americanus* (363), *Hippoglossina oblonga* (325), *Lophius americanus* (305), *Peprilus triacanthus* (284), *Paralichthys dentatus* (272), and *Squalus acanthias* (224).

INTRODUCTION

The Sandy Hook Laboratory of the National Marine Fisheries Service began a systematic survey during June 1974 of benthic fishes occurring in the New York Bight and Sandy Hook, Lower, and Raritan Bays. This study was designed to provide a comprehensive data base for current and anticipated research needs. This paper contains tabulations of stations, catches, and environmental data collected during this 13-mo study.

These data, when compared with similar time series, will ultimately contribute a significant portion of the material needed to detect and understand natural and man-induced changes in relative abundance, distribution, movements, conditions, and reproductive cycles of fishes occurring in the New York Bight.

STUDY AREAS

The New York Bight is that portion of the Atlantic continental shelf between eastern Long Island, N.Y., and Cape May, N.J. (Fig. 1). This study was conducted in the northern section of the New York Bight where the Long Island and New Jersey coastlines are nearly perpendicular.

Two study areas, ocean and bay, were designated to facilitate sampling and data handling. The ocean study area was delineated by two sets of imaginary lines and the 28- and 366-m isobaths (Fig. 2). The first set of lines extends seaward from points on Long Island and New Jersey to the 28-m isobath; the second set from the 28-m isobath to the edge of the continental shelf (366 m). The bay study area included Sandy Hook, Lower, and Raritan Bays (Fig. 3).

STATION SELECTION

Station locations in the ocean survey area were selected by a stratified random sampling design (Steel and Torrie 1960). Strata boundaries were determined by depth, i.e., 0-10, 11-19, 20-28, 29-55, 56-110, 111-183, and 184-366 m (Fig. 2). A minimum of two stations per stratum were randomly selected to be sampled during each cruise. Inshore strata (0-28 m) were sampled at a rate of approximately one station per 515 km^2 and offshore strata (29-366 m) at a rate of approximately one station per 1,030 km^2. Grosslein (1969) described additional details pertaining to this sampling method and design.

The bay survey area was divided into 103 sampling blocks. Except where interrupted by land, each block measured 1′ of latitude by 1′ of longitude, i.e., 1.8 km × 1.4 km (2.5 km^2). Trawl stations for all bay cruises were selected randomly from these blocks at the beginning of the study and were retained as permanent stations throughout the study.

MATERIALS AND METHODS

Research vessels used during this study were the 10.4-m *Xiphias* and 19.8-m *Rorqual* from the Northeast Fisheries Center, the 47.2-m *Delaware II* and 57.0-m *Albatross IV* from the National Ocean Survey, and the chartered 27.4-m *Atlantic Twin*. *Xiphias* and *Rorqual* were used exclusively in the bay areas, *Delaware II* was used in both the ocean and the bay, and *Albatross IV* and *Atlantic Twin* were used only in the ocean.

Loran A navigation was the principal method used for positioning on ocean stations. Radar, land ranges, and visual sightings of buoys were used to position vessels on bay stations and some of the inshore ocean stations.

Temperature, salinity, and depth observations were made at each station. Vertical temperature profiles were

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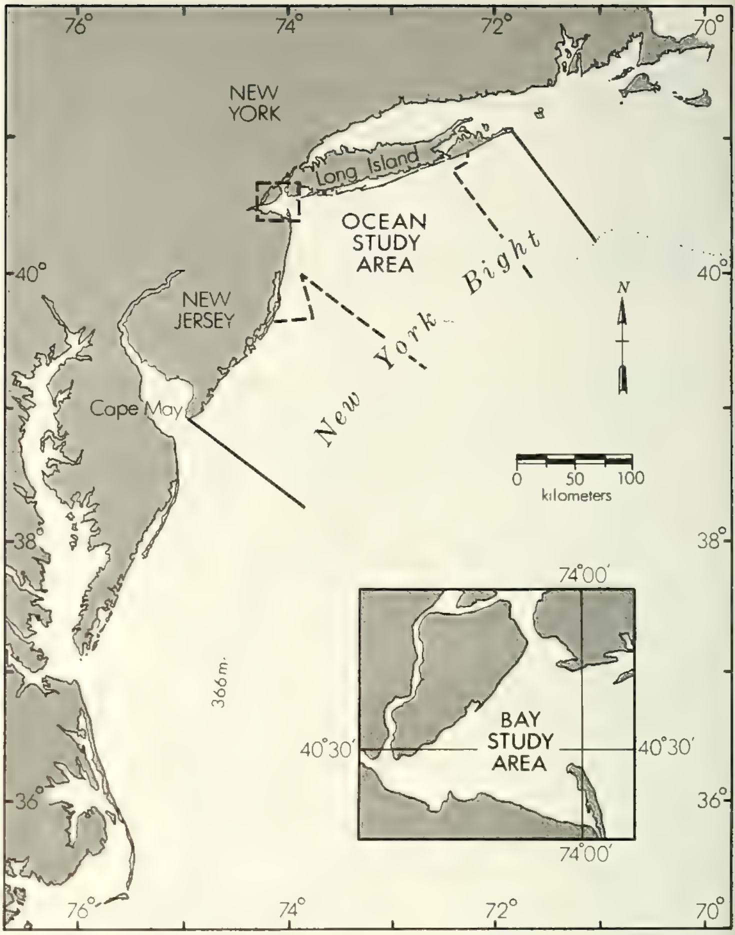

Figure 1.—Middle Atlantic continental shelf with outlines of the New York Bight (solid lines) and the survey areas (dashed lines) within the Bight.

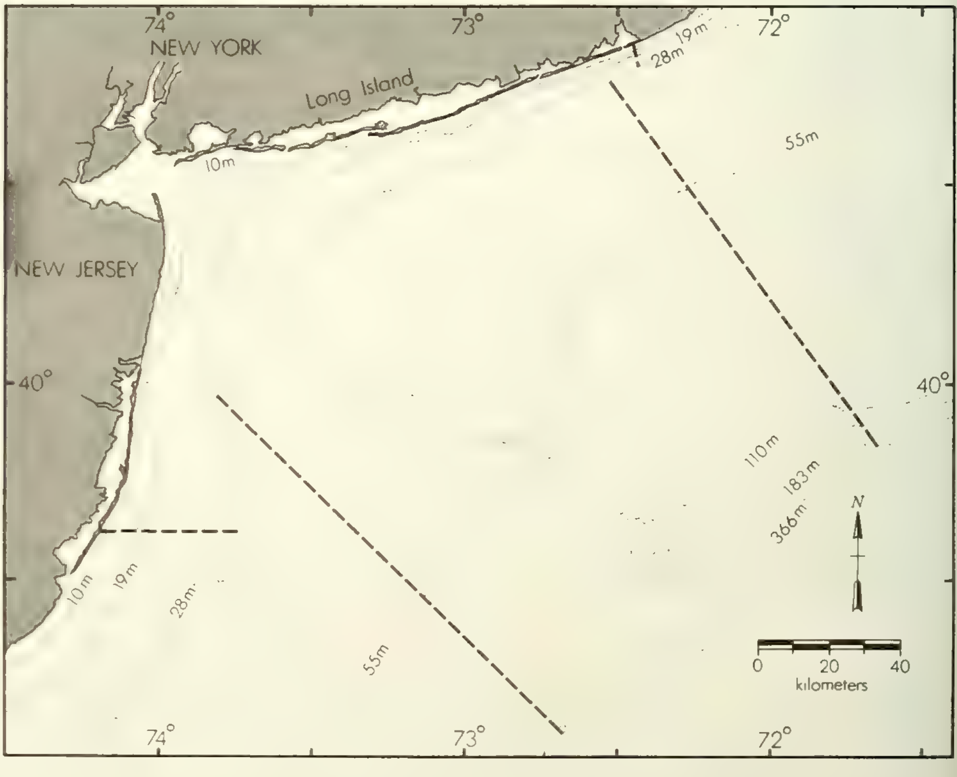

Figure 2.—Ocean study area divided into depth strata where finfishes were sampled during an otter trawl survey, June 1974 to June 1975.

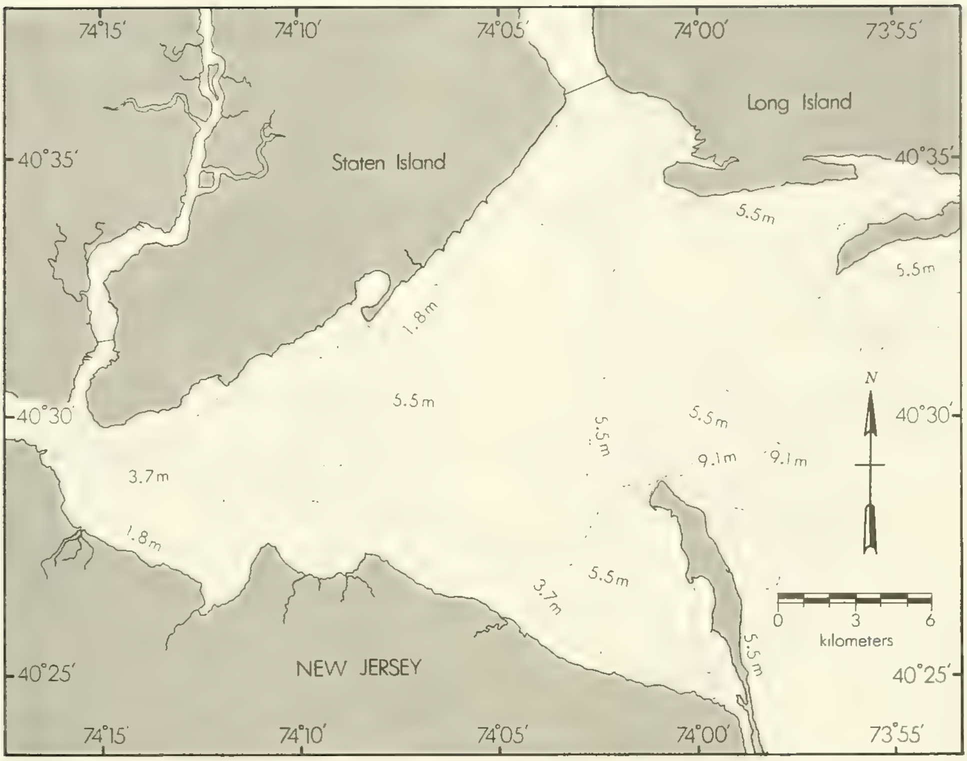

Figure 3.—Bay study area where finfishes were sampled during an otter trawl survey, June 1974 to June 1975.

obtained with expendable bathythermographs during ocean cruises and with a portable temperature probe during bay cruises. Surface water temperature was measured at each station with a stem thermometer accurate to ±0.1°C for calibration of the expendable bathythermograph and the probe. Surface and bottom water samples were taken at almost all stations for salinity determination by induction salinometer. Fathometers recorded depth during each trawl tow.

Fish collections were made with otter trawls towed at approximately 6.5 km/h for 15 min at bay stations and 30 min at ocean stations. The trawl used aboard *Xiphias* and *Rorqual* had a 9.1-m footrope, a 7.6-m headrope, and 7.6-m legs. a Yankee #36 trawl with a 24.4-m footrope, an 18.3-m headrope, and 9.1-m legs was used on *Delaware II*. The *Albatross IV* also used the #36 Yankee trawl as well as a #41 trawl with a 30.5-m footrope, a 24.4-m headrope, and 19.8-m top and 18.3-m bottom legs. The *Atlantic Twin* used a ¾ Yankee trawl with a 16.5-m footrope, an 11.9-m headrope, 11.6-m legs, and 16.5-m ground cables. All trawls were fitted with 12.7-mm stretch mesh cod end liners.

At the conclusion of each tow, the trawl was retrieved and emptied onto a sorting table where all fish species were separated and identified. All specimens of each species were weighed to the nearest whole pound and measured from the snout to the middle caudal ray in centimeters. All specimens of each species were usually measured except when subsamples of very large catches were measured. In such cases, an expansion factor (weight of total catch/weight of subsample) was applied to the number and length frequency of the subsample to estimate the number and length frequency of the total catch.

Samples of each bony fish species, up to 35 specimens, were frozen from each trawl station for subsequent laboratory study. If the total catch of a species exceeded 35 specimens, a size-stratified sample of 25 to 35 specimens was frozen.

Sources of identification and nomenclature used were: Jordan and Evermann (1896-1900), Hildebrand and Schroeder (1928), Ginsburg (1937, 1950, 1951, 1952, 1953, 1954), Hildebrand (1943), Breder (1948), Bigelow and Schroeder (1953), Berry and Anderson (1961), Casey (1964), Eschmeyer (1965), Anderson et al. (1966), Greenwood et al. (1966), Leim and Scott (1966), Gutherz (1967), Böhlke and Chaplin (1968), Randall (1968), Bailey et al. (1970), Rosenblatt and McCosker (1970), and Marshall and Iwamoto (1973).

DATA TABULATIONS

During this study, 700 trawl stations were occupied in 13 mo. Stations were consecutively numbered to aid in cross-referencing location, catch, and associated environmental data. Table 1 lists station numbers, vessel, dates, number of stations, gear type, and study area for each collecting interval. Table 2 provides station information including date, coordinates to the nearest 0.2 km, time of day (EST), trawling duration, number of species and individuals caught, total weight, depth, and surface and bottom temperature and salinity. Table 3 is a phylogenetic list of the 127 species and 67 families of fishes collected during this study including number and weight (kilograms) by station of occurrence. Unless indicated in Table 3, scientific and common names and arrangements are according to Bailey et al. (1970).

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Table 1.--Summary of collecting intervals sampled during trawl survey of New York Bight, June 1974 to June 1975.

Consecutive Sta. No.	Vessel	Date	No. of Sta.	Gear Type	Study Area
		1974			
1 - 15	*Xiphias*	June 3,4,6	15	9.1-m trawl	bay
16 - 18	*Delaware II*	June 3	3	# 36 trawl	bay
19 - 61	*Delaware II*	June 3-17	43	# 36 trawl	ocean
62 - 76	*Xiphias*	July 23-25	15	9.1-m trawl	bay
77 - 79	*Delaware II*	July 24	3	# 36 trawl	bay
80 - 120	*Delaware II*	July 24-29	41	# 36 trawl	ocean
121 - 136	*Rorqual*	Aug. 14,15,21-23	16	9.1-m trawl	bay
137 - 181	*Delaware II*	Aug. 16-21	45	# 36 trawl	ocean
182 - 193	*Xiphias*	Sept. 23-25	12	9.1-m trawl	bay
194 - 196	*Delaware II*	Sept. 23	3	# 36 trawl	bay
197 - 236	*Delaware II*	Sept. 23-28	40	# 36 trawl	ocean
237 - 255	*Xiphias*	Oct. 22-24	19	9.1-m trawl	bay
256 - 258	*Delaware II*	Oct. 22	3	# 36 trawl	bay
259 - 298	*Delaware II*	Oct. 22-28	40	# 36 trawl	ocean
299 - 317	*Xiphias*	Nov. 18-20	19	9.1-m trawl	bay
318 - 320	*Delaware II*	Nov. 18	3	# 36 trawl	bay
321 - 357	*Delaware II*	Nov. 18-25	37	# 36 trawl	ocean
		1975			
358 - 371	*Rorqual*	Jan. 3,6,9	14	9.1-m trawl	bay
372 - 385	*Rorqual*	Jan. 31; Feb. 3,4	14	9.1-m trawl	bay
386 - 388	*Delaware II*	Jan. 31	3	# 36 trawl	bay
389 - 439	*Delaware II*	Jan. 31; Feb. 1-6	51	# 36 trawl	ocean
440 - 458	*Albatross IV*	Mar. 6-8,10	19	# 41 trawl	ocean
459 - 485	*Atlantic Twin*	Mar. 20-24	27	3/4 Yankee trawl	ocean
486 - 500	*Rorqual*	Apr. 1,2,7	15	9.1-m trawl	bay
501 - 548	*Albatross IV*	Apr. 1-3,5-10	48	# 36 trawl	ocean
549 - 564	*Xiphias*	May 5-6,8	16	9.1-m trawl	bay
565 - 567	*Delaware II*	May 5	3	# 36 trawl	bay
568 - 627	*Delaware II*	May 5-12	60	# 36 trawl	ocean
628 - 636	*Xiphias*	June 3,9	9	9.1-m trawl	bay
637 - 700	*Delaware II*	June 2-9	64	# 36 trawl	ocean
TOTAL			700		

Table 2.--Summary of trawl stations made in New York Bight, June 1974 to June 1975. An asterisk (*) indicates a weight less than 0.5 kg and two asterisks (**) indicates data not taken.

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat. (N)	Long. (W)			No.	Wt. (kg)			Surface	Bottom	Surface	Bottom
	1974 June												
1	3	40°29.0'	74°03.0'	0958	15	5	4.5	4	8	16.4	15.4	22.8	23.7
2	3	40°28.8'	74°04.4'	1130	15	48	1.8	3	7	16.6	15.7	22.3	22.4
3	3	40°29.0'	74°05.8'	1310	15	9	0.5	3	7	18.6	15.2	21.8	25.5
4	3	40°27.8'	74°08.8'	1427	15	3	0.5	1	4	17.3	17.0	21.0	21.4
5	4	40°28.5'	74°12.7'	0830	15	NO FISH CAUGHT			5	17.8	16.9	20.9	21.8
6	4	40°30.4'	74°10.2'	0913	15	1	*	1	6	17.8	16.7	22.5	22.5
7	4	40°30.6'	74°05.8'	0955	15	2	1.4	2	6	17.6	16.0	22.2	23.0
8	4	40°27.8'	74°05.4'	1046	15	2	*	1	5	18.4	16.4	21.9	22.5
9	4	40°26.5'	74°02.5'	1137	15	22	2.7	7	5	18.2	16.0	22.4	24.2
10	4	40°27.5'	74°01.4'	1227	15	27	3.2	3	6	17.7	15.8	22.6	24.1
11	6	40°29.2'	74°01.4'	0809	15	2	*	2	6	16.5	16.4	26.1	26.1
12	6	40°30.0'	74°01.3'	0855	15	1	*	1	6	16.5	15.9	25.1	25.7
13	6	40°32.8'	74°05.3'	1040	15	NO FISH CAUGHT			5	17.0	16.5	22.4	24.0
14	6	40°33.0'	74°03.5'	1215	15	22	3.6	5	12	19.2	16.0	23.0	26.5
15	6	40°36.4'	74°02.7'	1335	15	NO FISH CAUGHT			33	18.0	16.2	20.1	26.2
16	3	40°29.0'	74°03.0'	0957	15	494	27.2	13	8	16.4	15.4	22.8	23.7
17	3	40°28.8'	74°04.4'	1130	15	2859	106.6	18	7	16.6	15.7	22.3	22.4
18	3	40°29.0'	74°05.8'	1315	15	2250	22.7	8	8	18.6	15.2	21.8	25.5
19	3	40°32.5'	73°41.5'	2224	30	806	93.9	16	15	15.4	14.1	30.9	30.9
20	4	40°30.0'	73°40.0'	0017	30	520	51.7	11	18	15.3	13.0	31.0	31.0
21	4	40°31.5'	73°36.5'	0152	30	476	73.4	18	19	15.5	13.9	31.0	31.1
22	4	40°22.0'	73°29.0'	0340	30	36	18.1	10	26	14.0	10.2	31.0	31.6
23	4	40°32.0'	73°27.0'	0525	30	88	45.8	11	15	13.6	13.1	30.9	31.0
24	4	40°33.5'	73°21.0'	0644	30	153	56.7	7	20	13.8	13.2	30.7	31.1
25	4	40°31.5'	73°17.0'	0815	30	34	40.8	4	26	14.0	10.5	30.8	31.6
26	4	40°22.5'	72°59.5'	1023	30	2	0.5	1	38	15.3	7.2	31.7	33.2
27	4	40°34.0'	73°03.0'	1203	30	68	31.8	8	24	13.5	11.2	31.0	30.5
28	4	40°39.3'	73°01.0'	1324	30	469	50.3	16	14	14.6	11.9	30.6	30.8
29	4	40°43.0'	72°49.5'	1501	30	953	42.2	14	16	15.2	12.3	30.7	30.9
30	4	40°43.5'	72°43.0'	1630	30	158	37.2	8	26	14.3	11.0	30.8	31.7
31	4	40°29.0'	72°22.0'	1905	30	31	20.0	10	53	14.3	6.9	32.4	32.8
32	4	40°05.0'	72°12.0'	2148	30	37	10.4	6	74	13.1	6.5	32.5	32.8
33	5	30°50.5'	71°56.5'	0017	30	90	2.7	6	134	14.5	12.8	33.7	35.0
34	5	39°46.0'	72°15.0'	0227	30	52	5.0	8	97	12.8	11.6	32.6	34.7
35	5	39°30.5'	72°10.5'	0450	30	5	*	4	242	13.0	12.0	33.4	35.6
36	5	39°30.5'	72°12.0'	0620	30	182	6.4	13	223	13.0	11.8	**	**
37	5	39°31.5'	72°32.5'	0835	30	28	5.4	7	99	19.2	16.4	33.6	34.0
38	5	39°23.0'	72°20.0'	1025	30	800	108.4	4	145	19.0	17.2	35.4	35.8
39	5	39°12.0'	72°28.5'	1258	30	124	17.7	10	322	22.5	8.9	35.0	34.2
40	5	39°20.0'	72°37.0'	1506	30	8	6.4	3	119	14.8	13.6	35.5	31.6
41	5	39°41.0'	72°59.5'	1807	30	12	3.6	5	55	16.7	7.8	33.5	33.1
42	5	39°44.0'	73°16.0'	1947	30	36	7.7	8	40	16.4	8.0	31.7	32.8
43	5	39°50.5'	73°35.0'	2145	30	61	10.0	10	33	13.2	4.7	30.2	32.8
44	5	39°43.0'	73°54.5'	2359	30	129	28.1	10	23	17.1	9.0	30.8	33.6
45	6	39°51.0'	73°58.0'	0124	30	184	36,3	11	17	17.1	11.9	29.8	32.3
46	6	39°56.0'	74°03.2'	0245	30	1004	88.5	12	16	15.4	12.8	29.9	32.0
47	6	39°58.5'	73°57.0'	0424	30	40	38.6	10	17	15.5	11.1	30.9	31.7
48	6	40°06.0'	74°01.0'	0544	30	361	56.7	10	15	14.7	11.8	30.2	31.7
49	6	40°12.0'	73°49.0'	0720	30	31	17.7	7	27	16.0	8.7	30.2	32.2
50	6	40°13.0'	73°54.0'	0816	30	385	71.2	12	22	16.3	11.8	30.9	31.7
51	6	40°18.0'	73°50.0'	0923	30	29	26.8	9	27	16.6	7.9	30.5	31.3
52	6	40°24.0'	73°54.3'	1130	30	189	86.6	9	17	18.3	12.3	30.4	32.3
53	6	40°27.0'	73°51.5'	1322	30	473	89.8	17	19	18.4	11.5	28.5	31.5
54	6	40°24.5'	73°47.5'	1513	30	53	29.9	10	35	16.5	7.3	28.8	32.8
55	6	40°16.0'	73°44.0'	1915	30	42	10.0	8	30	16.6	8.0	32.2	30.4
56	6	40°13.0'	73°37.0'	2035	30	34	20.4	8	35	16.7	7.8	32.1	31.7
57	6	40°12.0'	73°31.0'	2150	30	73	33.1	12	38	15.8	7.4	31.1	32.1
58	6	40°15.0'	73°35.0'	2356	30	95	12.7	12	27	16.4	9.0	31.1	31.9
59	7	40°20.3'	73°45.8'	0150	30	56	26.8	10	28	16.2	7.8	**	32.4
60	7	40°24.0'	73°44.5'	0317	30	49	17.7	8	24	15.6	8.7	30.6	30.4
61	7	40°32.3'	73°48.5'	0503	30	887	31.3	10	10	15.6	**	30.2	30.1

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
	July												
62	23	40°26.9'	74°05.0'	0845	15	18	1.4	4	6	21.9	22.0	26.9	26.4
63	23	40°27.0'	74°02.8'	0930	15	86	9.1	6	8	21.0	22.0	27.1	27.0
64	23	40°27.0'	74°02.0'	1025	15	3	1.4	2	7	21.0	22.0	27.2	27.5
65	24	40°29.5'	74°03.0'	0828	15	16	8.2	3	9	20.5	22.0	26.9	27.4
66	24	40°29.0'	74°02.0'	0923	15	13	22.7	4	8	20.7	21.0	27.1	27.1
67	24	40°26.9'	74°06.0'	1017	15	21	11.3	5	9	21.0	20.5	26.4	27.3
68	24	40°29.2'	74°06.3'	1056	15	26	11.3	9	10	21.0	20.7	26.8	26.9
69	24	40°25.3'	74°00.3'	1339	15	11	5.0	4	7	21.5	21.0	26.8	27.8
70	24	40°28.0'	74°03.2'	1419	15	46	14.5	7	7	20.9	21.0	27.7	27.4
71	25	40°33.7'	74°03.1'	0948	15	10	2.7	7	11	20.3	19.0	28.3	28.6
72	25	40°32.9'	74°05.6'	1021	15	1	*	1	6	20.0	19.8	27.0	27.2
73	25	40°31.0'	74°01.0'	1110	15	3	*	2	6	19.8	19.3	27.9	29.0
74	25	40°30.8'	74°05.0'	1147	15	2	*	2	7	20.0	20.2	26.7	27.1
75	25	40°30.6'	74°09.0'	1230	15	7	*	1	6	20.9	21.0	26.5	26.8
76	25	40°28.0'	74°10.0'	1310	15	2	3.6	2	4	21.0	20.9	26.0	26.1
77	24	40°27.0'	74°05.0'	0829	15	55	93.9	10	8	21.9	22.0	26.9	27.4
78	24	40°26.9'	74°03.0'	1015	15	205	44.0	7	7	21.0	22.0	26.4	27.3
79	24	40°29.2'	74°06.2'	1157	15	876	29.0	9	9	21.0	22.0	26.8	26.9
80	24	40°30.0'	73°43.0'	1338	30	409	76.2	10	18	19.2	13.5	30.2	32.5
81	24	40°31.5'	73°32.9'	1510	30	518	26.8	9	15	19.6	**	30.4	31.2
82	24	40°24.0'	73°31.0'	1646	30	555	52.6	9	22	20.4	13.8	30.9	32.3
83	24	40°26.6'	73°25.3'	1812	30	125	45.8	9	24	19.9	13.5	30.4	32.5
84	24	40°31.5'	73°28.0'	1940	30	225	97.1	13	16	19.5	15.1	30.3	32.4
85	24	40°34.0'	73°18.0'	2125	30	171	70.3	14	18	20.1	15.9	31.3	32.6
86	24	40°26.5'	73°16.5'	2359	30	514	148.8	10	27	20.3	14.1	31.2	32.8
87	25	40°23.8'	72°52.4'	0406	30	387	112.9	12	39	20.1	12.9	31.4	31.5
88	25	40°36.1'	73°01.4'	0706	30	111	5.9	4	20	19.9	10.9	32.0	32.4
89	25	40°39.0'	72°51.5'	1108	30	70	10.0	5	25	20.4	14.9	32.7	31.8
90	25	40°44.0'	72°47.8'	1231	30	5244	59.9	16	15	20.4	20.4	31.0	31.8
91	25	40°44.5'	72°40.0'	1421	30	1382	23.1	6	21	20.1	14.1	31.7	32.3
92	25	40°48.1'	72°33.2'	1546	30	18002	109.8	15	17	18.9	17.9	31.6	31.8
93	26	40°35.4'	72°36.5'	0246	30	166	24.5	11	33	20.3	11.1	31.5	32.9
94	26	40°17.3'	72°37.6'	0642	30	113	22.2	13	52	20.2	8.8	31.7	33.2
95	26	39°58.5'	72°42.0'	1035	30	9	13.6	3	57	21.8	7.3	33.1	33.5
96	26	39°47.5'	72°33.5'	1346	30	36	6.4	10	64	21.6	8.5	33.0	33.8
97	26	39°47.8'	72°23.5'	1515	30	34	3.2	6	82	21.5	9.9	32.8	34.4
98	26	40°02.8'	72°17.0'	1723	30	28	11.8	7	75	21.0	8.9	33.1	33.9
99	26	39°49.0'	71°46.0'	2222	30	290	57.6	13	329	22.5	8.2	34.8	35.1
100	27	39°37.8'	71°59.0'	0049	30	107	11.8	11	262	21.8	9.0	34.1	35.1
101	27	39°34.5'	72°13.9'	0413	30	60	5.0	9	123	21.8	13.1	33.9	36.0
102	27	39°24.1'	72°16.2'	0606	30	22	8.6	5	227	21.6	18.5	33.6	35.7
103	27	39°11.0'	72°34.5'	1338	30	13	0.9	2	161	22.9	12.5	34.8	35.9
104	27	39°27.5'	72°49.0'	2030	30	102	8.6	10	62	22.7	8.4	33.6	33.7
105	28	39°52.0'	73°01.0'	0011	30	1044	135.6	15	60	22.3	7.3	32.5	33.2
106	28	40°04.3'	73°02.8'	0410	30	113	16.8	12	46	21.7	8.3	32.0	33.2
107	28	39°55.3'	73°18.2'	0613	30	545	122.5	12	51	21.6	9.0	32.1	33.2
108	28	39°53.0'	73°48.5'	0858	30	71	6.4	3	27	22.5	12.9	31.4	32.6
109	28	39°53.5'	74°02.5'	1132	30	797	5.0	6	15	22.1	16.2	31.0	31.9
110	28	39°56.3'	73°54.0'	1302	30	1211	27.2	4	22	22.4	13.5	31.4	32.4
111	28	39°59.4'	74°02.6'	1441	30	1190	39.9	13	15	22.2	15.7	30.9	31.8
112	28	40°04.2'	73°36.1'	1720	30	1451	86.6	12	42	23.5	10.7	30.0	33.0
113	28	40°14.0'	73°35.0'	2001	30	42	7.7	9	33	22.5	14.1	30.9	32.8
114	28	40°17.0'	73°39.0'	2115	30	41	9.5	8	27	22.1	14.1	28.5	32.4
115	28	40°24.0'	73°41.0'	2228	30	979	169.6	13	26	20.9	14.8	31.0	32.4
116	29	40°26.0'	73°41.0'	0012	30	920	156.9	9	27	21.3	14.5	**	**
117	29	40°23.0'	73°34.0'	0136	30	310	60.8	13	22	21.6	14.9	30.9	32.6
118	29	40°10.0'	73°51.0'	0448	30	1011	21.8	8	24	22.1	14.5	30.8	32.3
119	29	40°14.0'	73°48.0'	0612	30	166	18.6	7	33	22.3	13.9	31.0	32.5
120	29	40°17.5'	73°53.4'	0717	30	1144	33.6	12	30	21.2	16.5	29.5	32.0

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
	Aug.												
121	14	40°29.1'	74°01.9'	0826	15	NO FISH CAUGHT			5	23.6	22.9	26.8	28.5
122	14	40°31.0'	74°01.2'	0904	15	5	2.3	3	5	25.5	22.9	27.0	27.5
123	14	40°33.4'	74°03.3'	1016	15	16	7.7	6	6	24.5	23.4	26.2	28.7
124	15	40°25.2'	74°00.5'	1115	15	39	0.5	4	6	27.0	24.5	26.3	26.4
125	15	40°26.1'	74°02.2'	1210	15	3	*	2	5	26.5	23.2	25.7	26.8
126	15	40°27.0'	74°03.9'	1255	15	33	*	3	5	25.5	23.5	26.1	26.9
127	21	40°32.2'	74°05.2'	0726	15	NO FISH CAUGHT			4	23.4	23.2	27.6	27.7
128	21	40°30.9'	74°05.2'	0807	15	71	0.5	2	3	23.5	22.8	26.6	28.4
129	21	40°30.8'	74°05.2'	0850	15	NO FISH CAUGHT			6	23.3	22.9	27.2	28.0
130	21	40°30.5'	74°09.1'	1051	15	18	0.5	2	6	24.3	24.0	27.5	27.5
131	21	40°28.7'	74°14.6'	1136	15	16	1.4	3	6	24.3	23.0	26.3	26.4
132	21	40°27.7'	74°09.9'	1254	15	4	8.6	1	4	24.9	24.5	25.6	26.3
133	22	40°29.4'	74°03.0'	0821	15	2	0.9	2	8	23.5	23.6	27.6	28.0
134	22	40°29.5'	74°06.2'	0905	15	5	3.6	5	9	23.8	23.6	27.6	27.5
135	22	40°27.1'	74°05.1'	1004	15	2	0.5	2	6	23.8	23.6	27.3	27.3
136	23	40°27.8'	74°01.3'	0812	15	116	7.3	6	7	23.8	23.8	27.6	27.6
137	16	40°32.0'	73°55.0'	1225	30	461	363.8	10	12	22.2	22.3	31.6	31.5
138	16	40°31.5'	73°53.5'	1358	30	474	86.6	11	11	22.7	22.0	30.8	31.5
139	16	40°33.3'	73°39.0'	1554	30	9970	37.6	11	16	22.5	21.1	31.6	31.7
140	16	40°31.8'	73°36.7'	1714	30	1869	36.3	13	20	22.5	19.1	31.7	32.0
141	16	40°26.0'	73°33.0'	1925	30	147	32.2	10	27	22.7	17.1	31.7	32.3
142	16	40°28.0'	73°26.3'	2052	30	244	37.6	14	24	21.4	17.1	32.7	32.7
143	16	40°33.0'	73°28.5'	2248	30	173	17.7	17	16	22.2	20.1	31.6	31.8
144	17	40°34.0'	73°23.0'	0004	30	485	38.6	17	18	22.3	19.8	31.6	31.8
145	17	40°31.0'	73°13.5'	0115	30	187	35.8	12	24	21.9	17.2	32.0	32.6
146	17	40°24.1'	73°05.2'	0407	30	78	21.8	9	40	21.2	10.9	32.6	33.5
147	17	40°33.8'	73°03.0'	0557	30	1136	47.2	9	29	21.8	13.8	32.1	33.0
148	17	40°37.5'	73°08.0'	0746	30	181	37.2	8	19	20.5	18.5	32.4	32.5
149	17	40°36.5'	72°55.0'	0925	30	55	17.7	10	30	**	13.9	32.3	33.1
150	17	40°42.0'	72°54.5'	1207	30	3146	48.1	19	15	21.4	17.8	32.3	32.6
151	17	40°43.5'	72°43.5'	1359	30	89	85.7	9	23	21.5	17.7	32.3	32.8
152	18	40°13.5'	72°36.5'	0122	30	499	117.0	15	54	21.8	8.4	32.8	33.8
153	18	40°13.7'	72°44.5'	0245	30	561	131.5	13	52	21.3	8.7	32.4	33.6
154	18	40°01.2'	73°00.6'	0547	30	26	8.6	8	49	21.7	8.5	32.2	33.6
155	18	39°55.5'	73°20.0'	0907	30	302	72.6	14	49	22.2	8.5	32.1	33.6
156	18	39°45.5'	73°15.0'	1045	30	655	30.4	12	45	22.3	10.7	32.5	33.6
157	18	39°46.0'	73°00.5'	1223	30	238	38.6	13	67	22.6	8.4	32.9	34.0
158	18	39°36.1'	72°42.6'	1538	30	64	12.7	10	72	22.5	8.9	33.5	34.0
159	18	39°47.8'	72°43.5'	1727	30	19	3.2	6	56	22.9	8.4	34.5	**
160	18	40°09.0'	72°20.0'	2148	30	398	143.8	11	68	22.6	9.6	33.9	34.3
161	19	39°55.5'	72°00.5'	0119	30	989	78.0	10	89	22.4	18.3	34.9	36.4
162	19	39°45.5'	71°58.4'	0318	30	397	24.5	12	146	23.3	13.5	35.7	36.5
163	19	39°40.8'	71°56.5'	0500	30	232	17.7	15	267	23.0	9.0	35.4	35.0
164	19	39°11.0'	72°27.5'	1319	30	362	21.8	19	330	23.9	7.8	35.1	36.4
165	19	39°17.8'	72°27.6'	1457	30	6	128.4	3	139	23.6	13.2	34.7	36.5
166	19	39°17.1'	72°37.5'	1751	30	1822	110.2	7	127	23.4	13.4	34.1	36.4
167	19	39°30.5'	73°03.0'	2235	30	388	40.4	14	66	22.2	8.1	33.2	34.0
168	20	39°46.0'	73°55.0'	0402	30	71	7.3	12	25	23.4	14.0	32.2	33.3
169	20	39°48.6'	74°01.0'	0515	30	264	6.8	3	17	21.4	16.2	32.0	32.8
170	20	39°56.3'	74°02.9'	0636	30	25	0.9	3	18	21.0	17.0	32.0	32.7
171	20	39°51.0'	73°57.0'	0813	30	83	2.3	6	21	23.0	14.4	32.2	33.1
172	20	40°01.0'	73°45.0'	1058	30	53	6.8	8	33	23.2	13.3	31.9	32.6
173	20	40°08.8'	73°57.0'	1240	30	107	1.4	3	17	23.2	16.3	31.7	33.5
174	20	40°10.0'	73°47.0'	1403	30	2653	74.8	7	33	23.9	13.1	**	**
175	20	40°10.0'	73°41.0'	1533	30	1832	111.1	10	49	23.7	9.2	32.3	33.7
176	20	40°03.5'	73°35.0'	1728	30	1585	68.5	7	42	23.2	10.8	32.0	33.7
177	20	40°13.6'	73°26.7'	2011	30	195	18.1	9	38	23.6	12.5	32.3	33.6
178	20	40°19.0'	73°36.0'	2140	30	383	10.9	10	26	23.4	15.4	32.1	33.0
179	20	40°23.0'	73°41.0'	2257	30	278	12.2	11	27	23.8	15.9	31.5	33.1

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
180	21	40°25.0'	73°41.0'	0002	30	112	8.6	7	28	23.9	15.3	31.6	33.0
181	21	40°23.0'	73°51.0'	0218	10	37	5.4	5	25	22.6	15.3	30.5	33.0
	Sept.												
182	23	40°28.9'	74°05.3'	0915	15	200	2.7	6	8	19.8	19.5	**	**
183	23	40°29.4'	74°07.2'	1145	15	39	*	5	9	**	**	25.6	25.5
184	23	40°30.6'	74°05.9'	1301	15	610	3.6	8	8	19.0	19.5	24.6	25.1
185	23	40°26.7'	74°01.3'	1410	15	22	8.2	6	8	20.0	19.3	26.0	27.0
186	24	40°29.2'	74°01.5'	0801	15	89	3.2	8	5	18.2	18.3	25.8	25.7
187	24	40°33.3'	74°03.2'	0910	15	306	6.8	9	6	18.4	19.0	23.4	24.9
188	24	40°32.6'	74°05.5'	1030	15	985	6.4	4	5	18.6	18.4	23.8	24.8
189	24	40°30.5'	74°09.3'	1201	15	1441	9.5	8	6	18.7	18.5	25.3	25.4
190	24	40°28.6'	74°13.5'	1255	15	238	1.4	5	5	18.9	18.7	23.6	23.6
191	24	40°27.8'	74°08.8'	1348	15	30	0.9	4	3	19.4	18.9	24.0	24.1
192	25	40°26.4'	74°02.6'	0810	15	198	3.6	9	5	17.4	16.6	24.5	24.5
193	25	40°27.8'	74°05.0'	0913	15	74	8.2	8	6	18.8	18.5	24.9	24.9
194	23	40°29.0'	74°05.0'	0912	15	1865	11.8	8	7	19.8	19.5	**	**
195	23	40°29.0'	74°05.0'	1142	15	545	17.2	12	8	**	**	25.6	25.5
196	23	40°30.0'	74°05.0'	1258	15	30371	57.6	9	7	19.0	19.5	24.6	25.1
197	23	40°30.0'	73°53.0'	1449	30	621	131.1	13	12	18.9	16.5	30.1	32.2
198	23	40°31.9'	73°49.1'	1603	30	3451	93.4	19	11	18.8	16.4	30.8	32.5
199	23	40°33.9'	73°42.4'	1733	30	724	72.6	17	12	18.2	16.7	32.0	32.6
200	23	40°29.2'	73°40.1'	1851	30	228	147.9	16	18	18.2	12.9	31.5	32.6
201	23	40°17.8'	73°42.2'	2039	30	112	49.0	12	26	19.1	14.6	31.4	31.5
202	23	40°17.8'	73°37.7'	2152	30	179	66.2	16	25	**	**	31.4	32.5
203	23	40°15.0'	73°37.0'	2316	30	72	145.6	13	26	18.5	19.4	31.7	32.5
204	24	40°15.9'	73°34.8'	0058	30	135	57.6	16	25	18.2	16.9	31.5	32.5
205	24	40°19.6'	73°32.6'	0243	30	165	298.0	15	25	18.5	18.9	31.5	32.2
206	24	40°25.0'	73°31.7'	0421	30	313	57.2	16	25	18.4	18.4	31.6	32.4
207	24	40°28.8'	73°26.7'	0648	30	88	112.5	13	20	18.8	19.5	31.3	32.7
208	24	40°31.5'	73°29.2'	1020	30	14381	59.0	15	16	17.6	17.1	31.3	32.2
209	24	40°33.5'	73°25.0'	1130	30	2797	93.9	19	16	17.6	17.5	31.3	32.1
210	24	40°37.0'	73°11.8'	1333	30	8022	74.4	19	13	17.5	17.1	31.8	32.2
211	24	40°31.8'	73°08.4'	1728	30	1612	102.1	15	29	**	**	31.9	32.6
212	24	40°38.1'	73°05.4'	1850	30	1989	53.5	24	13	17.5	17.3	31.1	32.2
213	24	40°38.5'	72°55.0'	2021	30	215	158.3	10	26	17.5	17.1	32.0	32.7
214	24	40°40.8'	72°52.8'	2328	30	513	98.0	20	21	17.6	17.9	32.2	32.3
215	25	40°46.0'	72°40.5'	0113	30	12386	168.7	27	14	17.0	16.8	32.4	32.4
216	25	40°32.2'	72°31.0'	1013	30	172	24.5	11	43	17.5	14.3	32.7	33.1
217	25	39°59.0'	71°58.5'	2200	30	576	46.3	16	86	19.7	11.0	34.2	34.6
218	26	39°48.0'	71°50.5'	0134	30	324	13.6	17	21	19.6	11.3	34.9	35.4
219	26	39°39.0'	72°17.8'	0431	30	218	6.4	7	115	20.1	15.5	34.5	34.8
220	26	39°23.4'	72°21.6'	0635	30	39	6.4	2	141	21.0	12.6	34.8	35.7
221	26	39°13.0'	72°26.5'	1129	30	529	23.6	12	297	21.4	11.8	35.0	35.6
222	26	39°22.4'	72°29.2'	1334	30	107	9.5	4	131	**	**	34.8	35.7
223	26	39°43.7'	72°40.7'	1842	30	534	76.7	10	69	19.3	11.0	33.9	33.7
224	26	39°57.0'	72°35.0'	2154	30	412	78.5	11	60	18.7	10.8	33.6	33.2
225	26	40°06.5'	72°31.0'	2338	30	398	66.2	14	59	18.7	10.8	33.3	33.3
226	27	40°04.0'	72°39.0'	0058	30	537	176.0	16	60	18.7	10.4	33.4	33.0
227	27	40°09.5'	73°05.9'	0414	30	227	62.1	14	46	18.5	14.5	33.6	**
228	27	39°59.2'	73°19.0'	0618	30	3269	228.6	17	66	19.0	11.0	32.9	32.9
229	27	39°54.0'	73°19.5'	0755	30	186	46.3	11	49	19.0	10.4	32.1	32.8
230	27	39°46.5'	73°11.5'	1041	30	74	20.4	9	38	18.8	10.3	32.5	33.0
231	27	39°48.3'	73°22.0'	1211	30	19935	559.3	9	39	20.0	10.3	**	32.9
232	27	39°45.5'	74°03.4'	1722	30	427	157.9	17	13	19.9	19.1	30.8	31.7
233	27	39°48.4'	73°58.8'	1840	30	373	186.9	19	20	**	**	31.6	31.9
234	27	40°05.5'	74°00.0'	2220	30	369	98.8	12	18	**	**	31.6	32.1
235	27	40°04.0'	73°56.0'	2342	30	171	93.9	12	19	**	**	31.2	32.1
236	28	40°07.5'	73°48.8'	0143	30	275	113.4	16	33	**	**	31.6	32.3
	Oct.												
237	22	40°28.9'	74°04.8'	0920	15	357	4.1	12	8	10.9	11.4	24.7	26.0
238	22	40°29.3'	74°06.6'	1030	15	543	2.7	11	9	10.4	11.4	24.4	25.6

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
239	22	40°29.9'	74°08.2'	1210	15	4714	2.7	5	9	11.8	11.2	24.1	26.4
240	22	40°30.6'	74°06.1'	1300	15	289	0.5	7	6	12.0	11.8	24.9	25.2
241	22	40°29.9'	74°03.9'	1339	15	18	0.5	4	8	12.4	11.7	24.5	25.3
242	23	40°27.9'	74°01.1'	0827	15	141	15.0	13	6	9.4	10.4	23.7	24.0
243	23	40°26.8'	74°02.4'	0919	15	42	5.0	6	6	9.5	10.2	22.9	23.6
244	23	40°27.9'	74°03.1'	1000	15	50	5.4	3	6	10.4	10.6	23.7	25.1
245	23	40°27.6'	74°05.1'	1145	15	485	0.5	3	5	10.7	10.5	23.8	23.9
246	23	40°27.4'	74°09.1'	1230	15	64	4.5	6	3	11.5	11.4	23.3	23.8
247	23	40°28.5'	74°11.1'	1300	15	25	0.9	3	4	12.3	11.6	22.9	24.8
248	23	40°28.7'	74°13.5'	1326	15	39	0.9	2	4	12.4	11.5	23.3	24.8
249	23	40°30.3'	74°09.9'	1407	15	81	2.7	5	6	12.4	10.6	24.9	25.6
250	24	40°25.9'	74°00.2'	0817	15	21	0.9	5	5	9.1	10.3	23.1	25.5
251	24	40°29.1'	74°01.3'	0910	15	83	0.5	4	5	11.6	11.7	24.8	25.6
252	24	40°31.1'	73°58.8'	1015	15	20	*	1	7	12.8	12.8	26.2	27.8
253	24	40°31.2'	74°01.2'	1127	15	11	*	2	5	12.6	12.4	24.8	25.8
254	24	40°33.8'	74°03.1'	1206	15	12	1.4	6	3	12.1	11.8	21.9	25.5
255	24	40°32.8'	74°05.3'	1250	15	13	4.5	2	4	11.8	11.5	24.6	**
256	22	40°29.0'	74°05.0'	0920	15	2392	32.2	18	8	10.9	11.4	24.7	26.0
257	22	40°29.0'	74°07.0'	1025	15	5339	22.2	12	7	10.4	11.4	24.4	25.6
258	22	40°29.0'	74°07.0'	1205	15	15499	32.7	15	5	11.8	11.2	24.1	26.4
259	22	40°28.0'	73°52.0'	1403	30	1063	355.2	19	18	13.6	13.5	30.9	31.8
260	22	40°31.0'	73°48.0'	1831	30	696	430.0	20	17	13.2	14.2	32.2	32.3
261	22	40°34.0'	73°47.0'	2009	30	341	465.4	20	12	12.9	13.5	31.7	31.9
262	22	40°34.0'	73°43.0'	2153	30	587	148.3	18	11	13.2	13.4	31.8	31.9
263	22	40°32.0'	73°36.8'	2359	30	520	109.8	20	14	13.3	13.4	31.9	31.9
264	23	40°28.2'	73°40.6'	0148	30	528	727.1	17	22	13.4	13.4	32.2	32.1
265	23	40°25.7'	73°36.9'	0335	30	451	435.4	15	20	14.0	14.2	32.1	32.1
266	23	40°24.0'	73°33.0'	0540	30	1272	626.4	23	26	14.0	14.2	32.0	32.0
267	23	40°10.0'	73°18.5'	0726	30	1069	335.7	11	36	14.8	14.7	32.5	32.5
268	23	40°28.6'	73°12.8'	1142	30	3385	390.1	15	28	13.8	14.4	32.5	32.9
269	23	40°27.5'	73°20.5'	1358	30	3531	248.1	12	25	14.2	14.6	32.1	32.3
270	23	40°32.5'	73°26.8'	1548	30	2600	65.3	18	16	14.7	14.6	31.9	31.9
271	23	40°32.0'	73°23.0'	1718	30	450	199.6	20	18	14.2	14.1	31.9	31.9
272	23	40°36.0'	73°16.0'	1905	30	903	75.3	26	16	13.4	13.4	31.7	31.7
273	23	40°37.5'	73°10.0'	2108	30	613	111.1	24	17	13.6	13.6	31.9	31.9
274	23	40°34.0'	73°09.0'	2255	30	888	430.4	23	23	13.6	13.6	32.0	32.3
275	24	40°39.0'	73°01.8'	0112	30	300	75.3	17	17	13.5	13.6	32.0	32.1
276	24	40°37.0'	72°55.3'	0230	30	2139	957.5	20	29	13.6	13.7	32.2	32.7
277	24	40°34.7'	72°49.0'	0434	30	979	656.3	16	33	14.2	14.4	32.8	33.0
278	24	40°46.0'	72°41.0'	0835	30	471	360.6	19	19	14.3	14.2	32.3	32.3
279	24	40°46.0'	72°33.0'	1027	30	816	1020.1	14	20	13.4	13.4	32.5	32.5
280	25	40°21.0'	72°40.5'	0250	30	481	95.7	18	48	14.2	12.4	33.0	33.3
281	25	40°08.5'	72°52.7'	0505	30	250	93.4	18	49	14.3	13.0	33.2	33.3
282	25	39°58.0'	72°47.0	0840	30	99	52.6	13	55	14.3	10.5	33.1	33.2
283	25	40°03.5'	72°30.0'	1038	30	108	56.7	11	59	15.0	10.5	33.1	33.6
284	25	40°07.0'	72°25.0'	1217	30	37	18.1	6	62	15.0	10.5	34.0	33.9
285	25	39°58.5'	72°05.6'	1817	30	63	19.5	8	81	14.7	11.3	**	**
286	26	39°43.0'	71°51.5'	0208	30	387	91.6	11	348	15.5	7.5	**	**
287	26	39°51.5'	71°48.5'	0624	30	12	8.6	5	165	15.4	13.2	**	**
288	26	39°46.0'	72°12.5'	0910	30	81	12.2	8	97	14.5	12.8	33.9	35.0
289	26	39°12.0'	72°26.5'	1750	30	139	20.0	17	288	15.5	8.6	34.7	35.3
290	26	39°14.5'	72°42.5'	2159	30	1344	86.6	12	113	15.8	14.8	34.7	35.5
291	27	39°37.0'	72°50.0'	0434	30	200	115.7	10	63	14.0	13.7	**	**
292	27	39°51.0'	73°01.5'	1035	30	187	190.5	10	75	14.0	10.5	33.2	33.4
293	27	39°52.5'	73°49.0'	1848	30	1084	939.4	20	15	14.1	14.3	**	**
294	27	39°50.0'	74°01.5'	2113	30	414	78.5	21	15	13.4	13.8	31.3	31.8
295	27	40°05.0'	73°55.0'	2222	30	1076	1225.2	17	22	13.4	14.3	31.7	31.3
296	28	40°05.0'	73°32.0'	0143	30	168	112.9	14	62	14.1	10.5	32.8	33.0
297	28	40°20.0'	73°44.0'	0516	30	2882	953.9	14	24	14.0	14.3	32.7	32.8
298	28	40°24.0'	73°57.0'	0828	30	5804	79.4	20	12	13.1	14.2	31.0	31.6

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
299	Nov. 18	40°28.4'	74°04.1'	1037	15	134	5.4	11	8	10.5	9.8	**	27.1
300	18	40°29.1'	74°05.6'	1130	15	102	2.3	13	9	10.2	9.6	**	26.5
301	18	40°29.6'	74°08.1'	1314	15	71	1.8	9	8	10.4	10.1	**	26.8
302	18	40°29.1'	74°03.5'	1506	15	45	0.5	9	7	10.5	10.4	**	29.9
303	19	40°29.0'	74°01.5'	0906	15	16	4.5	7	5	9.8	9.8	**	27.4
304	19	40°31.1'	74°01.1'	0950	15	23	2.3	3	5	11.4	10.7	**	26.4
305	19	40°33.2'	74°00.2'	1035	15	5	0.5	3	5	13.4	10.6	**	30.4
306	19	40°33.3'	74°03.2'	1121	15	232	3.6	10	7	11.9	11.1	**	25.4
307	19	40°32.5'	74°05.2'	1212	15	15	1.4	6	5	12.8	11.2	**	25.2
308	19	40°30.5'	74°05.3'	1301	15	37	2.7	8	6	12.4	10.7	**	26.6
309	19	40°27.4	74°05.5'	1354	15	54	0.9	11	5	11.5	9.7	**	23.4
310	19	40°27.1'	74°03.2'	1441	15	71	5.4	11	5	11.1	10.6	**	28.3
311	19	40°27.5'	74°01.6'	1521	15	105	6.4	9	8	12.0	10.1	**	29.1
312	20	40°30.3'	74°09.1'	0947	15	65	3.6	9	5	10.0	9.5	**	25.2
313	20	40°28.4'	74°13.3'	1049	15	27	1.4	5	5	10.8	9.8	**	25.3
314	20	40°28.3'	74°11.5'	1126	15	86	3.2	9	5	10.8	9.4	**	25.7
315	20	40°27.5'	74°10.0'	1253	15	45	1.4	7	4	10.4	10.1	**	24.8
316	20	40°26.5'	74°02.5'	1353	15	135	9.5	9	6	10.7	10.1	**	28.8
317	20	40°25.2'	74°00.2'	1445	15	46	5.9	5	6	9.8	9.7	**	26.4
318	18	40°28.0'	74°04.0'	1033	15	533	33.1	18	8	10.6	9.7	23.8	27.0
319	18	40°29.0'	74°05.0'	1122	15	590	23.6	14	8	10.2	9.6	**	**
320	18	40°29.0'	74°08.0'	1310	15	945	53.5	18	8	10.4	10.1	25.5	26.9
321	18	40°30.2'	73°51.0'	1720	30	638	36.3	20	12	12.0	13.0	32.3	33.5
322	18	40°33.8'	73°51.0'	1910	30	645	63.5	22	8	12.1	12.4	33.2	33.1
323	18	40°34.0'	73°38.0'	2045	30	529	88.5	19	11	12.3	12.7	33.3	33.3
324	18	40°26.0'	73°27.0'	2235	30	349	149.9	25	26	12.1	12.4	33.1	33.1
325	19	40°35.5'	73°25.0'	0022	30	1130	190.5	26	8	10.5	10.9	32.2	32.1
326	19	40°36.0'	73°21.0'	0231	30	3089	151.0	18	13	11.5	11.3	32.0	32.0
327	19	40°37.0'	73°14.5'	0517	30	9898	235.9	21	15	10.5	10.3	32.3	32.2
328	19	40°21.5'	72°53.5'	0950	30	164	162.8	10	46	12.4	13.1	33.3	33.5
329	19	40°34.0'	72°57.5'	1146	30	171	77.6	19	30	12.0	12.4	32.4	32.9
330	19	40°39.0'	72°52.4'	1428	30	745	249.9	20	24	11.7	12.3	32.3	32.7
331	19	40°41.6'	72°55.0'	1620	30	565	124.3	17	15	10.9	11.0	32.3	32.3
332	19	40°46.0'	72°42.5'	1810	30	1574	248.1	17	10	11.1	13.3	32.4	32.6
333	19	40°49.5'	72°30.5'	1950	30	2280	452.7	17	10	11.8	11.5	32.9	32.6
334	19	40°49.5'	72°27.5'	2157	30	823	169.2	17	14	11.4	12.0	32.8	33.0
335	20	40°30.0'	72°30.0'	0953	30	303	254.0	17	46	12.7	13.1	33.4	33.7
336	20	40°00.8'	72°51.5'	1531	30	130	149.2	15	51	12.3	13.1	34.0	34.7
337	20	39°48.5'	72°31.5'	1935	30	334	193.2	17	67	12.9	13.7	**	**
338	20	39°57.5'	72°31.0'	2235	30	321	151.0	16	47	13.1	13.6	**	**
339	21	40°09.0'	72°20.5'	0036	30	200	113.4	12	68	12.9	13.1	34.1	34.1
340	21	40°11.2'	72°12.8'	0225	30	338	170.1	19	66	13.4	13.2	34.0	34.1
341	21	40°19.0'	73°35.0'	2204	30	261	181.9	15	26	11.1	11.3	32.8	32.8
342	23	40°03.5'	73°21.7'	0043	30	1089	555.2	16	45	10.8	12.4	33.4	34.0
343	23	39°57.0'	73°10.0'	0342	30	574	477.2	15	64	9.4	13.0	**	**
344	23	39°44.3'	71°53.5'	1700	30	299	45.8	11	237	13.5	**	34.6	35.7
345	23	39°48.0'	71°56.5'	1845		GEAR LOST			148	12.2	14.2	34.5	36.0
346	23	39°36.7'	72°25.5'	2230	30	808	283.0	15	335	13.4	11.4	34.8	35.9
347	24	39°26.8'	72°22.0'	0054	30	121	6.8	16	131	13.6	13.1	**	**
348	24	39°23.4'	72°36.0'	0400	30	298	8.6	12	112	13.5	13.9	35.0	35.8
349	24	39°28.5'	72°43.5'	0610	30	421	526.6	11	64	12.5	13.9	34.2	35.2
350	24	39°43.0'	73°03.5'	0932	30	194	114.8	9	50	12.3	13.2	34.3	34.4
351	24	39°46.0'	73°13.5'	1110	30	81	104.3	7	46	12.3	13.0	34.0	34.7
352	24	39°46.1'	73°58.8'	1622	30	198	478.1	13	20	11.4	11.5	32.8	32.7
353	24	40°01.0'	73°49.0'	1902	30	176	180.5	18	28	11.3	11.6	33.0	33.4
354	24	40°09.0'	73°50.8'	2032	30	177	145.6	19	24	10.7	12.1	32.7	33.9
355	24	40°16.0'	73°46.0'	2158		GEAR LOST			49	10.9	12.3	32.7	33.7
356	25	40°24.0'	73°41.0'	0042	30	212	108.4	15	24	11.1	11.0	32.5	33.2
357	25	40°08.5'	73°33.8'	0303	30	334	336.6	16	35	11.3	12.3	33.4	33.9

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
	1975 Jan.												
358	3	40°29.1'	74°01.5'	1017	15	35	2.3	5	7	5.0	6.0	28.3	28.2
359	3	40°31.0'	74°01.2'	1058	15	27	1.8	6	7	6.1	6.0	28.4	29.2
360	3	40°33.3'	74°00.4'	1140	15	26	0.9	4	7	7.0	6.5	32.5	33.4
361	3	40°33.5'	74°03.1'	1314	15	36	0.9	9	5	6.0	6.0	26.3	27.2
362	3	40°32.5'	74°05.2'	1358	15	28	0.9	6	5	5.8	5.3	26.6	27.0
363	3	40°30.4'	74°05.4'	1435	15	20	*	3	7	5.8	5.2	26.1	26.9
364	6	40°25.2'	74°00.2'	0948	15	73	4.5	7	6	3.6	4.8	23.9	23.5
365	6	40°27.5'	74°01.1'	1045	15	112	1.8	4	6	4.5	6.3	24.5	26.5
366	6	40°27.1'	74°03.5'	1230	15	137	2.7	6	7	4.8	6.0	25.1	26.1
367	6	40°29.1'	74°03.0'	1307	15	31	0.5	3	7	5.4	6.2	25.6	26.9
368	6	40°29.3'	74°06.1'	1346	15	26	0.5	3	9	5.8	5.8	26.3	26.6
369	6	40°27.5'	74°05.6'	1433	15	25	0.5	4	7	5.4	5.8	26.2	26.6
370	9	40°28.3'	74°13.5'	1328	15	4	0.5	2	3	6.2	6.2	22.5	22.4
371	9	40°28.5'	74°11.0'	1404	15	68	2.3	8	3	6.2	5.9	24.8	24.2
372	31	40°28.5'	74°04.5'	0952	15	35	0.5	3	9	4.7	4.8	25.8	26.1
373	31	40°30.0'	74°07.5'	1218	15	92	1.4	6	9	4.8	4.7	26.5	25.6
374	31	40°29.0'	74°06.0'	1355	15	524	12.2	6	8	4.3	4.8	23.3	25.0
	Feb.												
375	3	40°27.2'	74°03.4'	1447	15	195	9.5	7	6	4.2	4.3	22.1	22.9
376	3	40°29.0'	74°01.5'	0935	15	36	0.9	7	5	4.0	4.2	24.1	24.0
377	3	40°31.1'	74°01.1'	1015	15	17	0.5	2	5	4.1	4.4	20.6	22.7
378	3	40°33.3'	74°00.0'	1058	15	2	*	1	6	4.4	4.5	23.9	24.3
379	3	40°33.5'	74°03.0'	1140	15	28	0.5	6	6	4.2	5.3	23.7	28.2
380	3	40°32.6'	74°03.0'	1307	15	NO FISH CAUGHT			5	4.1	4.3	23.9	23.9
381	3	40°30.3'	74°05.2'	1347	15	22	1.8	3	7	4.2	4.2	24.0	22.4
382	3	40°29.3'	74°04.0'	1429	15	2	*	1	8	4.2	4.3	22.9	22.4
383	4	40°28.2'	74°14.0'	1255	15	12	2.7	4	4	3.5	3.8	24.8	20.7
384	4	40°28.0'	74°12.0'	1330	15	13	*	1	6	2.9	3.4	22.7	20.4
385	4	40°30.3'	74°10.0'	1405	15	18	0.5	3	6	2.4	2.8	20.8	21.6
	Jan.												
386	31	40°29.0'	74°05.0'	0950	15	1815	24.0	10	10	4.7	4.8	25.8	26.1
387	31	40°29.0'	74°07.0'	1122	15	416	9.1	12	8	5.0	4.7	26.5	25.6
388	31	40°30.0'	71°08.0'	1216	15	1372	17.7	10	8	4.8	**	23.3	25.0
389	31	40°28.0'	73°50.0'	1415	30	815	70.8	11	17	6.4	7.3	32.1	33.6
390	31	40°34.0'	73°41.0'	1556	30	227	62.1	17	8	4.8	6.2	31.7	32.2
391	31	40°31.2'	73°37.3'	1728	30	277	67.6	15	17	5.8	6.0	32.7	32.8
392	31	40°29.8'	73°36.7'	1958	30	662	150.6	17	20	6.0	7.2	32.7	33.4
393	31	40°26.0'	73°36.5'	2155	30	481	89.4	19	22	5.5	7.0	32.4	33.3
394	31	40°29.3'	73°31.0'	2335	30	426	60.8	14	23	5.6	6.4	32.4	32.6
	Feb.												
395	1	40°32.5'	73°27.0'	0108	30	522	62.1	14	19	5.6	6.2	32.2	32.6
396	1	40°25.0'	73°24.3'	0230	30	671	133.4	14	29	5.0	6.0	32.4	32.6
397	1	40°24.2'	73°15.3'	0355	30	414	176.9	16	31	5.0	5.9	33.0	33.0
398	1	40°11.5'	73°15.0'	0545	30	409	142.4	16	38	5.6	6.8	33.3	33.4
399	1	40°32.0'	73°13.0'	0928	30	421	59.9	15	21	5.0	5.4	32.6	32.7
400	1	40°36.0'	73°16.5'	1044	30	553	68.5	16	15	5.0	5.2	34.4	32.3
401	1	40°39.5'	73°02.3'	1232	30	423	147.0	14	15	5.0	5.3	32.2	32.2
402	1	40°37.2'	73°01.0'	1346	30	318	82.1	14	22	5.2	4.8	32.1	32.6
403	1	40°40.0'	72°53.0'	1504	30	243	79.8	12	27	3.8	5.0	32.5	32.7
404	1	40°44.0'	72°48.5'	1741	30	431	101.2	11	15	3.8	4.5	32.4	32.5
405	1	40°47.1'	72°29.5'	1940	30	510	131.1	16	24	4.1	5.3	32.7	33.0
406	2	40°36.1'	72°32.5'	0523	30	473	126.6	10	40	5.2	5.8	33.4	33.3
407	2	40°26.2'	72°44.8'	0723	30	153	76.7	10	44	6.0	6.8	33.7	33.7
408	2	40°05.0'	72°45.0'	1256	30	214	234.5	6	55	8.4	8.4	34.3	34.4
409	2	40°16.5'	72°17.8'	1549	30	181	199.1	9	57	8.2	8.5	34.1	34.1
410	2	40°04.0'	72°02.0'	2055	30	517	169.7	17	76	7.6	10.4	34.2	34.8
411	3	39°44.2'	71°56.9'	0619	30	27	10.4	4	172	11.2	13.7	36.0	36.1
412	3	39°52.0'	71°45.0'	0945	30	32	5.0	4	219	8.1	11.5	34.8	36.0
413	3	39°58.3'	72°08.7'	1408	30	109	49.9	13	82	8.2	11.2	34.2	34.9
414	3	39°56.4'	72°20.2'	1630	30	189	99.3	11	74	8.8	10.2	34.6	34.6
415	3	39°51.5'	72°44.0'	2312	30	332	223.2	14	69	8.2	9.0	34.5	34.5

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
416	4	39°45.6'	72°38.0'	0115	30	316	143.8	14	62	8.8	9.0	34.6	34.3
417	4	39°36.0'	72°24.0'	0348	30	116	70.8	12	283	8.2	9.1	34.2	36.1
418	4	39°33.4'	72°12.4'	0742	30	45	8.6	2	134	11.6	13.1	36.8	36.9
419	4	39°30.0'	72°26.0'	0925	30	6	1.8	1	126	8.9	12.9	34.3	35.9
420	4	39°09.1'	72°32.8'	1648	30	162	29.5	13	342	12.8	9.3	36.1	35.7
421	4	39°26.0'	72°57.5'	2224	30	287	132.4	11	59	8.5	8.9	34.7	34.7
422	5	39°38.0'	72°45.3'	0158	30	509	304.4	15	69	8.5	9.3	34.2	34.6
423	5	39°46.2'	73°07.0'	0426	30	267	519.4	7	47	8.5	8.4	34.5	34.5
424	5	39°55.6'	73°14.0'	0807	30	781	537.1	9	75	7.4	8.2	**	**
425	5	39°45.0'	73°27.5'	1150	30	101	65.8	6	33	7.8	7.2	**	**
426	5	39°40.5'	74°04.1'	1614	30	113	26.3	12	16	5.0	5.0	32.9	**
427	5	39°46.3'	73°58.4'	1855	30	297	67.6	12	21	5.3	5.1	**	**
428	5	39°52.0'	74°03.0'	2034	30	433	86.2	11	15	5.4	5.2	**	**
429	5	39°54.5'	74°01.0'	2212	30	342	58.1	13	16	5.4	5.3	32.0	32.6
430	6	39°59.0'	73°52.5'	0151	30	240	72.1	19	24	6.2	**	32.8	**
431	6	40°04.5'	73°55.0'	0314	30	258	64.0	14	23	6.2	6.6	33.2	**
432	6	39°57.5'	73°35.4'	0520	30	196	79.4	16	30	6.4	5.4	33.8	**
433	6	40°16.0'	73°33.0'	0925	30	478	136.5	13	27	5.4	5.4	32.8	33.0
434	6	40°13.0'	73°35.0'	1127	30	403	114.3	14	28	5.7	5.8	33.2	33.3
435	6	40°10.6'	73°38.6'	1257	30	418	124.3	12	36	5.9	6.0	33.3	**
436	6	40°11.0'	73°47.0'	1448	30	510	132.0	11	35	6.2	6.0	33.3	33.3
437	6	40°16.0'	73°45.0'	1558	30	955	289.8	20	31	5.9	6.0	33.0	33.0
438	6	40°16.5'	73°54.0'	1736	30	244	57.2	12	21	5.4	5.8	30.3	33.3
439	6	40°21.8'	73°48.1'	1926	30	118	11.8	26	37	5.7	6.1	32.3	33.7
	Mar.												
440	6	39°51.5'	71°45.0'	1112	30	321	85.7	14	207	7.1	9.8	34.9	36.4
441	6	39°48.5'	71°48.0'	1318	30	209	135.6	13	229	7.6	9.4	34.8	35.5
442	6	40°01.5'	71°53.5'	1600	30	309	75.3	10	84	7.8	10.3	34.8	35.7
443	6	40°34.5'	72°21.5'	2315	30	227	64.0	11	44	6.2	7.5	34.2	34.6
444	7	40°16.5'	72°12.0'	0206	30	264	107.5	12	61	6.9	6.8	34.9	34.9
445	7	40°19.5'	72°48.0'	0524	30	362	88.9	12	48	5.1	6.4	34.8	34.6
446	7	40°09.5'	73°10.0'	0752	30	34	22.7	10	41	5.2	5.7	34.8	35.0
447	7	39°59.0'	72°33.0'	1144	30	279	300.7	11	66	7.3	7.3	35.5	35.6
448	7	39°45.0'	72°34.5'	1449	30	268	137.0	9	79	7.5	7.3	35.5	35.6
449	7	39°33.5'	72°13.0'	1728	30	93	9.1	12	135	7.9	11.3	35.6	**
450	7	39°20.0'	72°20.5'	2310	30	108	8.6	13	169	8.0	12.5	35.4	36.6
451	8	39°26.0'	72°27.5'	0129	30	66	6.8	15	122	7.5	12.1	35.4	36.5
452	8	39°50.5'	72°59.0'	1327	30	797	1326.8	9	71	7.7	7.7	35.4	35.4
453	8	39°53.5'	73°06.0'	1519	30	386	446.8	9	68	6.7	7.4	34.8	**
454	8	39°50.5'	73°21.0'	1751	30	326	131.1	11	44	6.4	6.5	34.8	34.8
455	8	39°47.0'	73°09.0'	1928	30	409	127.9	10	46	7.1	7.1	35.0	35.4
456	8	39°36.5'	72°54.5'	2131	30	479	792.4	6	64	7.3	7.3	35.4	35.5
457	8	39°29.0'	72°52.0'	2313	30	145	161.0	6	65	8.3	8.3	35.5	35.8
458	10	39°12.0'	72°28.5'	0225	30	127	50.3	18	302	9.0	10.8	35.7	36.2
459	18	40°30.2'	73°46.5'	1735	30	114	27.7	8	18	5.0	5.0	32.9	34.0
460	18	40°34.5'	73°43.0'	2006	30	211	64.0	10	9	4.6	4.6	32.5	32.5
461	18	40°32.1'	73°33.1'	2244	30	209	36.7	13	16	4.4	4.4	32.7	32.7
462	19	40°32.8'	73°27.2'	0218	30	142	37.2	13	15	4.4	4.4	33.0	32.8
463	19	40°29.3'	73°24.7'	0312	30	150	31.8	13	25	4.3	4.3	32.9	32.9
464	19	40°25.0'	73°24.8'	0450	30	110	33.1	12	27	4.3	4.4	33.1	33.1
465	19	40°24.4'	73°32.8'	0633	30	15	7.3	6	22	4.5	4.5	32.4	**
466	20	40°24.9'	73°55.1'	0732	30	54	10.0	7	17	5.2	5.1	**	32.1
467	20	40°19.3'	73°53.2'	0855	30	53	24.9	10	19	5.2	4.8	28.9	32.2
468	20	40°17.5'	73°56.0'	1054	30	NO FISH CAUGHT			18	5.2	4.7	29.3	31.7
469	20	40°12.6'	73°59.6'	1336	30	NO FISH CAUGHT			13	5.0	4.9	32.2	32.2
470	20	40°06.5'	74°04.7'	1500	30	101	24.0	10	22	5.3	5.0	31.6	32.7
471	21	40°02.0'	74°02.0'	1120	30	74	20.9	8	16	5.1	5.0	32.2	31.7
472	21	39°57.3'	73°57.0'	1306	30	25	11.3	6	21	5.5	5.1	31.8	31.6
473	21	39°50.0'	73°56.7'	1515	30	23	9.5	7	20	5.6	5.1	31.9	32.4
474	21	39°49.5'	74°04.8'	1717	30	95	36.7	11	8	5.4	5.3	32.0	32.0
475	21	39°42.5'	73°57.0'	1905	30	81	23.1	9	22	5.3	5.2	32.3	32.1

Table 2.--Continued

Sta.		Location		Start	Duration	Total Catch		No. spp.	Depth	Temp. (°C)		Salinity (o/oo)	
No.	Date	Lat.(N)	Long.(W)	Time	(min)	No.	Wt.(kg)	Caught	(m)	Surface	Bottom	Surface	Bottom
476	22	39°47.5'	73°48.0'	1912	30	31	20.4	11	24	5.2	5.1	33.2	33.3
477	22	40°05.5'	73°50.0'	2220	30	52	13.2	9	24	5.3	4.8	32.6	32.5
478	23	40°17.8'	73°42.7'	1900	30	79	25.4	8	24	5.1	4.9	33.5	33.7
479	23	40°24.7'	73°34.7'	2059	30	206	55.8	12	24	5.0	4.8	33.6	33.7
480	23	40°35.1'	73°20.7'	2340	30	196	31.3	13	16	5.2	4.8	33.0	33.3
481	24	40°32.7'	73°08.4'	0201	30	54	23.1	8	26	5.3	4.9	33.1	33.3
482	24	40°37.2'	73°01.1'	0344	30	55	22.2	9	22	5.3	4.9	33.0	33.3
483	24	40°40.7'	72°56.9'	0521	30	39	7.3	8	17	5.0	4.8	33.0	33.0
484	24	40°47.7'	72°37.2'	0744	30	144	84.4	16	6	5.0	4.8	33.3	33.4
485	24	40°47.5'	72°28.5'	0917	30	22	10.4	10	26	5.1	4.8	33.2	33.4
486	Apr. 1	40°28.0'	74°01.0'	1125	15	21	3.2	6	7	6.5	5.7	20.6	25.3
487	1	40°27.0'	74°02.0'	1235	15	14	1.8	7	11	7.5	6.0	20.6	25.9
488	1	40°27.2'	74°03.4'	1315	15	4	*	3	6	6.6	6.0	21.2	25.2
489	1	40°29.0'	74°03.4'	1400	15	10	1.4	5	7	6.4	6.5	23.0	26.2
490	1	40°29.6'	74°03.4'	1415	15	4	0.5	2	5	6.8	6.5	22.4	25.3
491	1	40°31.0'	74°01.0'	1450	15	5	1.8	2	5	**	**	22.1	25.2
492	2	40°25.0'	74°00.5'	0915	15	2	*	2	5	6.4	5.5	20.5	20.4
493	2	40°30.1'	74°05.0'	1030	15	49	2.3	3	6	6.5	5.8	20.4	24.2
494	2	40°30.1'	74°06.0'	**	15	11	0.5	4	6	6.3	5.3	21.2	21.3
495	2	40°30.4'	74°09.0'	1218	15	2	0.5	2	5	6.8	5.3	23.0	23.1
496	2	40°28.6'	74°11.0'	1300	15	102	0.9	3	5	6.2	4.5	20.3	20.4
497	2	40°28.6'	74°13.0'	1445	15	73	0.5	4	4	6.5	5.0	19.3	21.5
498	7	40°33.5'	74°00.0'	1244	15	1	*	1	3	5.5	5.4	23.8	25.3
499	7	40°33.4'	74°03.0'	1328	15	2	*	2	9	5.3	5.0	19.3	25.7
500	7	40°32.4'	74°05.2'	1406	15	57	1.4	5	5	4.7	4.5	20.3	23.0
501	1	40°27.3'	73°46.4'	1747	30	175	33.6	10	27	5.0	5.5	29.8	33.4
502	1	40°30.0'	73°38.0'	1939	30	214	68.5	11	16	5.5	5.1	30.3	33.2
503	1	40°31.6'	73°38.7'	2046	30	269	49.9	13	16	5.5	5.2	29.9	33.2
504	1	40°32.5'	73°33.4'	2208	30	303	91.6	12	15	5.2	5.0	31.4	32.7
505	1	40°32.0'	73°26.0'	2326	30	310	50.3	12	18	5.2	4.5	32.2	32.6
506	2	40°18.5'	73°11.5'	0205	30	162	68.9	11	38	4.8	4.9	33.1	33.3
507	2	40°32.5'	73°11.0'	0500	30	274	59.4	12	24	4.8	4.7	32.4	32.8
508	2	40°32.5'	73°07.5'	0626	30	207	100.7	9	24	5.0	4.8	32.4	32.5
509	2	40°37.0'	73°09.0'	0750	30	126	41.7	13	13	4.8	4.6	32.5	32.4
510	2	40°40.0'	72°59.0'	0922	30	103	64.9	11	17	4.7	4.7	32.5	32.7
511	2	40°43.5'	72°49.5'	1329	30	214	66.2	14	16	5.0	5.0	32.5	32.9
512	2	40°45.4'	72°36.0'	1540	30	121	62.6	13	26	5.3	4.9	32.7	32.9
513	2	40°32.0'	72°29.0'	2326	30	151	86.2	14	46	5.3	5.3	**	33.1
514	3	40°24.0'	72°33.5'	0157	30	216	131.1	10	49	5.7	7.2	33.1	33.4
515	3	40°13.5'	72°32.0'	0457	30	219	214.1	9	57	6.3	6.1	**	**
516	3	40°19.0'	72°59.5'	0747	30	64	52.2	9	44	5.7	5.6	33.5	33.4
517	5	40°01.0'	74°02.0'	1248	30	59	15.9	8	17	4.8	4.8	32.4	32.3
518	5	39°52.5'	74°03.5'	1446	30	112	22.2	11	16	4.8	4.8	32.3	32.2
519	5	39°54.5'	73°59.5'	1601	30	27	22.7	10	18	4.9	4.9	32.7	32.7
520	5	40°00.0'	73°56.0'	1744	30	367	13.2	6	20	5.4	5.4	33.4	33.3
521	5	40°08.8'	73°55.0'	2108	30	175	35.8	14	18	4.6	5.0	32.1	32.8
522	5	40°13.5'	73°48.0'	2337	30	267	87.1	20	31	5.4	5.4	33.5	33.8
523	6	40°15.9'	73°33.8'	0329	30	173	28.1	6	29	4.4	4.4	32.4	32.3
524	6	40°00.0'	73°38.0'	0828	30	44	27.2	9	36	4.8	6.3	33.0	34.3
525	6	39°52.5'	73°29.0'	1125	30	43	62.6	11	38	5.6	6.3	33.8	34.1
526	6	40°03.5'	73°17.0'	1426	30	41	17.7	6	46	5.4	5.4	33.0	33.5
527	6	40°08.8'	72°55.6'	1831	30	93	106.1	9	47	5.9	5.9	33.7	33.7
528	7	40°03.5'	73°24.0'	0224	30	119	127.0	7	68	6.0	6.5	33.7	33.8
529	7	40°14.0'	72°09.0'	0540	30	185	383.7	11	66	5.3	5.3	33.7	33.6
530	7	40°09.0'	72°01.5'	0822	30	58	122.0	5	69	5.6	6.6	33.8	34.1
531	7	39°46.4'	71°49.4'	1518	30	142	32.2	12	311	7.0	8.8	34.0	35.4
532	7	39°43.0'	72°07.0'	1912	30	48	15.4	6	112	7.4	11.8	34.3	35.6
533	7	39°44.0'	72°14.5'	2322	30	51	51.3	10	104	7.5	11.2	34.2	35.6

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
534	8	39°47.5'	72°21.0'	0113	30	57	57.2	8	82	6.8	10.6	34.0	35.5
535	8	39°45.5'	72°39.0'	0554	30	271	225.9	12	75	6.7	7.4	33.9	34.1
536	8	39°34.0'	72°20.0'	0725	30	64	8.6	4	101	7.5	11.2	34.0	35.5
537	8	39°29.5'	72°19.0'	1015	30	117	20.4	20	366	7.5	11.8	34.2	35.7
538	8	39°14.0'	72°27.0'	1855	30	174	37.6	16	183	8.1	11.6	34.6	35.7
539	8	39°11.5'	72°37.0'	2112	30	46	8.2	14	139	8.0	12.3	34.5	35.7
540	8	39°19.0'	72°48.5'	2323	30	70	30.8	12	79	7.5	9.2	34.4	34.8
541	9	39°28.5'	72°58.5'	0354	30	179	205.9	6	66	6.6	6.6	34.0	34.1
542	9	39°34.1'	73°05.5'	0540	30	92	122.0	12	47	6.5	6.5	34.0	34.0
543	9	39°52.5'	72°51.0'	1030	30	155	120.7	11	64	6.6	6.6	34.0	34.0
544	9	39°54.5'	73°11.5'	1554	30	259	233.1	12	62	6.1	6.1	34.0	33.8
545	9	39°46.0'	73°10.0'	1854	30	259	156.5	13	46	8.6	8.4	33.9	33.9
546	10	40°26.2'	73°37.0'	0608	30	122	37.2	16	20	4.9	4.9	32.6	32.7
547	10	40°18.5'	73°49.0'	0912	30	44	14.5	9	38	4.9	6.1	32.4	34.6
548	10	40°16.3'	73°50.8'	1054	30	NO	FISH CAUGHT		26	5.0	5.0	32.5	32.5
	May												
549	5	40°28.5'	74°05.0'	**	15	8	1.4	4	7	11.4	10.8	21.5	21.6
550	5	40°29.2'	74°06.1'	**	15	14	1.8	5	8	10.9	11.4	21.3	21.6
551	5	40°30.1'	74°05.5'	**	15	13	1.4	2	7	11.5	10.4	21.2	23.0
552	5	40°30.5'	74°09.0'	**	15	5	0.5	2	4	11.2	10.9	20.8	20.7
553	6	40°29.1'	74°01.6'	**	15	34	*	4	5	11.0	10.2	19.7	27.7
554	6	40°33.5'	74°00.1'	**	15	56	2.7	7	4	11.4	10.4	17.7	24.1
555	6	40°33.6'	74°03.1'	**	15	25	0.9	8	5	12.3	12.2	23.1	19.1
556	6	40°32.6'	74°05.2'	**	15	72	2.3	11	4	13.9	11.6	19.3	20.4
557	6	40°28.5'	74°13.5'	**	15	55	4.1	7	4	15.0	14.1	14.9	21.2
558	6	40°28.4'	74°11.6'	**	15	161	15.4	8	4	14.9	13.6	16.1	21.2
559	6	40°27.5'	74°10.0'	**	15	47	3.2	7	3	14.5	13.3	16.3	20.4
560	6	40°27.5'	74°04.0'	**	15	58	10.4	9	5	**	**	20.9	23.9
561	8	40°29.1'	74°03.1'	**	15	47	9.5	8	7	12.7	11.5	19.9	22.6
562	8	40°27.6'	74°01.5'	**	15	78	14.5	5	7	12.1	13.2	20.2	21.0
563	8	40°26.5'	74°02.1'	**	15	127	17.7	4	5	14.4	12.3	19.9	20.8
564	8	40°25.2'	74°00.6'	**	15	85	7.3	8	5	14.8	14.0	20.1	20.9
565	5	40°28.8'	74°04.4'	1026	15	181	18.1	11	8	11.4	10.8	21.5	21.6
566	5	40°29.2'	74°06.2'	1111	15	211	17.7	11	9	10.9	11.4	21.3	21.6
567	5	40°29.3'	74°06.5'	1152	15	456	76.2	13	8	11.5	10.4	21.2	23.0
568	5	40°29.8'	73°54.0'	1350	30	1127	110.2	25	12	9.3	9.5	32.2	32.7
569	5	40°32.0'	73°48.0'	1519	30	329	91.2	16	15	8.6	8.5	32.7	32.6
570	5	40°34.2'	73°45.5'	1635	30	1708	198.7	22	11	9.0	8.9	32.7	32.7
571	5	40°29.6'	73°45.1'	1802	30	353	98.9	15	26	8.4	8.2	32.7	32.8
572	5	40°28.2'	73°35.8'	2004	30	721	83.0	17	21	8.3	8.0	32.9	33.0
573	5	40°25.3'	73°44.0'	2133	30	423	69.4	12	24	8.2	6.4	32.9	33.0
574	5	40°18.8'	73°37.0'	2308	30	445	51.7	13	26	7.8	6.7	33.1	33.3
575	6	40°15.4'	73°40.8'	0031	30	518	190.1	15	30	8.0	6.5	33.3	33.3
576	6	40°14.0'	73°45.0'	0203	30	508	106.5	13	50	8.4	6.3	33.0	33.2
577	6	40°17.8'	73°51.1'	0652	30	584	166.9	21	26	8.4	7.3	28.7	33.0
578	6	40°11.3'	73°49.0'	0835	30	360	123.4	17	26	8.8	7.0	31.0	33.1
579	6	40°11.5'	73°56.0'	0948	30	346	91.2	16	17	9.4	7.7	26.1	32.5
580	6	40°22.9'	73°55.8'	1503	30	364	71.2	18	15	10.8	7.5	26.9	32.9
581	6	40°30.0'	73°31.2'	1658	30	549	144.7	17	20	8.5	7.9	32.9	33.0
582	6	40°32.5'	73°29.0'	1936	30	625	121.1	16	17	8.5	8.3	32.8	32.0
583	6	40°34.0'	73°22.7'	2052	30	918	154.7	17	17	8.5	8.3	32.5	32.6
584	6	40°29.3'	73°18.9'	2226	30	461	214.1	18	24	7.7	7.7	32.0	32.6
585	7	40°19.5'	73°22.5'	0010	30	593	144.2	18	33	8.0	6.8	32.8	33.0
586	7	40°14.8'	73°16.5'	0210	30	326	98.9	16	39	7.8	6.1	32.7	33.4
587	7	40°27.0'	73°06.7'	0545	30	200	92.5	17	31	7.8	7.4	32.7	32.8
588	7	40°31.9'	73°07.4'	0705	30	407	215.4	17	24	7.6	7.6	32.3	32.4
589	7	40°36.3'	73°13.0'	0828	30	927	397.3	17	18	8.4	8.1	32.1	32.2
590	7	40°37.0'	73°09.0'	1028	30	1087	273.5	19	18	9.0	8.0	32.0	32.2
591	7	40°34.4'	73°00.5'	1158	30	129	144.7	18	23	8.5	7.5	32.1	32.6
592	7	40°39.5'	72°59.3'	1314	30	511	230.0	15	17	8.5	7.4	31.9	32.0
593	7	40°44.9'	72°44.7'	1609	30	675	226.8	18	18	9.5	7.6	**	**
594	7	40°44.6'	72°42.2'	1800	30	630	202.8	20	25	8.5	7.2	31.7	31.8

Table 2.--Continued

Sta.		Location		Start	Duration	Total Catch		No. spp.	Depth	Temp. (°C)		Salinity (o/oo)	
No.	Date	Lat.(N)	Long.(W)	Time	(min)	No.	Wt.(kg)	Caught	(m)	Surface	Bottom	Surface	Bottom
595	7	40°41.5'	72°37.0'	1948	30	460	137.4	14	32	7.8	6.9	31.8	**
596	7	40°28.5'	72°31.8'	2141	30	175	68.5	11	43	8.5	6.0	**	33.4
597	8	40°27.0'	72°27.0'	0023	30	198	83.9	13	47	7.5	5.6	32.4	**
598	8	40°21.7'	72°45.4'	1653	30	117	69.4	14	49	8.2	5.7	32.5	33.5
599	8	40°13.7'	72°59.0'	1851	30	107	49.9	14	47	9.3	5.6	32.6	33.2
600	8	40°01.1'	72°53.0'	2040	30	319	111.1	12	50	8.5	6.0	33.0	33.9
601	9	40°11.5'	72°32.7'	0033	30	1065	433.6	13	62	9.5	5.9	32.6	33.8
602	9	40°16.5'	72°07.3'	0300	30	164	53.1	12	62	7.3	5.4	33.3	33.7
603	9	40°03.8'	72°19.5'	0910	30	322	112.0	11	72	7.3	5.5	33.3	33.6
604	9	39°43.8'	72°00.6'	1612	30	74	34.9	14	153	9.5	11.9	34.0	36.0
605	9	39°52.5'	71°44.0'	2042	30	248	75.3	19	222	8.7	10.7	33.5	35.9
606	9	40°02.0'	71°55.2'	2255	30	50	14.5	10	83	9.0	5.6	33.6	33.7
607	10	39°55.2'	72°08.8'	0046	30	37	13.6	10	80	8.7	5.4	33.5	33.7
608	10	39°54.0'	72°41.3'	0430	30	101	42.6	18	54	9.0	5.9	33.5	33.7
609	10	39°46.2'	72°21.1'	0646	30	126	33.1	12	88	8.8	5.6	33.1	33.5
610	10	39°37.3'	72°22.8'	0816	30	103	17.2	10	105	8.5	11.5	33.5	35.8
611	10	39°30.4'	72°09.0'	1152	30	373	63.5	13	248	10.8	11.4	34.3	36.1
612	10	39°24.6'	72°14.4'	1348	30	314	93.9	15	348	10.6	9.0	34.2	35.8
613	10	39°14.5'	72°29.4'	1932	30	74	11.3	14	155	9.6	11.5	34.1	32.0
614	10	39°28.5'	72°43.0'	2335	30	39	15.9	7	70	9.2	5.7	32.6	33.7
615	11	39°40.4'	72°46.3'	0154	30	195	93.0	15	68	9.9	6.0	33.4	33.8
616	11	39°28.1'	73°05.6'	0540	30	217	90.7	14	65	9.5	6.2	33.3	33.8
617	11	39°38.2'	73°17.8'	1118	30	36	35.4	10	39	11.2	6.8	33.7	33.8
618	11	39°43.0'	73°01.8'	1310	30	49	25.4	13	51	11.2	6.2	33.3	33.7
619	11	39°54.0'	73°07.5'	1500	30	644	219.5	18	70	10.9	6.5	33.1	33.8
620	11	39°53.7'	73°27.1'	1821	30	98	50.8	14	41	11.9	6.2	32.1	33.4
621	11	39°54.0'	73°39.3'	1952	30	417	85.3	15	28	11.1	6.2	31.8	33.5
622	11	39°54.5'	73°49.0'	2125	30	443	212.3	17	27	11.4	6.3	31.3	33.3
623	12	39°52.5'	73°52.7'	0015	30	418	146.5	18	24	11.0	6.5	31.8	33.3
624	12	39°40.7'	74°05.4'	0233	30	301	116.6	17	15	11.3	8.8	31.6	32.6
625	12	39°47.6'	74°01.9'	0404	30	263	91.2	16	17	11.0	7.9	31.5	33.0
626	12	39°54.7'	74°03.4'	0528	8	332	117.9	18	18	9.4	8.1	32.2	32.7
627	12	40°04.0'	73°20.0'	1210	30	64	56.7	12	42	11.6	6.3	32.7	33.5
	June												
628	3	40°27.6'	74°03.1'	0805	15	116	3.2	10	7	20.6	20.4	20.1	21.2
629	3	40°27.5'	74°05.1'	0840	15	57	2.3	9	5	20.8	20.5	19.4	21.4
630	3	40°27.6'	74°09.1'	0930	15	37	1.8	5	3	20.4	19.4	20.0	22.8
631	3	40°28.3'	74°11.0'	0950	15	17	1.4	6	4	20.3	19.2	21.3	24.3
632	3	40°28.5'	74°13.0'	1025	15	2	*	2	3	**	**	19.5	23.5
633	3	40°30.3'	74°09.6'	**	15	21	0.5	5	5	**	**	22.2	25.5
634	9	40°29.1'	74°01.4'	0920	15	7	0.9	4	5	17.3	17.0	23.2	26.4
635	9	40°31.1'	74°01.1'	1040	15	16	0.5	4	5	16.9	16.5	24.4	25.2
636	9	40°32.2'	74°05.9'	1235	15	50	0.9	5	4	18.1	17.9	23.8	23.9
637	2	40°31.0'	73°54.7'	1623	30	243	68.0	10	10	16.5	15.0	30.7	31.5
638	2	40°31.0'	73°50.7'	1746	30	584	131.1	18	16	18.2	9.6	28.9	32.1
639	2	40°34.0'	73°39.8'	1915	30	531	106.6	16	9	15.9	13.5	31.7	31.7
640	2	40°27.3'	73°36.6'	2048	30	147	37.6	18	19	17.8	9.5	29.9	31.8
641	2	40°25.0'	73°41.0'	2210	30	289	86.2	18	24	17.6	8.6	30.3	32.5
642	2	40°22.3'	73°30.4'	2356	30	312	74.8	18	26	17.8	7.4	30.6	32.0
643	3	40°27.0'	73°35.2'	0115	30	339	114.8	16	22	17.8	10.0	30.2	32.0
644	3	40°32.0'	73°31.3'	0239	30	1124	264.0	14	15	17.2	12.8	30.9	31.9
645	3	40°35.1'	73°21.1'	0424	30	572	90.3	16	18	16.3	9.0	31.4	31.9
646	3	40°36.0'	73°16.7'	0634	30	249	122.9	10	18	16.6	8.2	31.4	31.8
647	3	40°33.0'	73°13.0'	0815	30	74	49.9	9	23	17.7	7.7	30.7	31.8
648	3	40°34.0'	73°08.5'	0937	30	107	105.7	10	21	17.6	7.5	31.0	**
649	3	40°37.0'	73°09.0'	1050	30	260	99.8	13	17	15.3	8.2	31.8	**
650	3	40°41.2'	72°56.5'	1225	30	752	136.1	17	15	16.7	8.8	31.4	32.0
651	3	40°39.3'	72°55.7'	1344	30	204	195.0	13	25	**	**	31.5	32.3
652	3	40°30.5'	72°49.3'	1635	30	117	51.3	10	38	16.0	7.0	31.6	32.8
653	3	40°43.6'	72°42.7'	1826	30	717	372.9	12	25	15.9	6.6	31.3	32.3

Table 2.--Continued

Sta. No.	Date	Location		Start Time	Duration (min)	Total Catch		No. spp. Caught	Depth (m)	Temp. (°C)		Salinity (o/oo)	
		Lat.(N)	Long.(W)			No.	Wt.(kg)			Surface	Bottom	Surface	Bottom
654	4	40°31.2'	72°23.1'	0346	30	177	59.0	14	46	15.7	5.4	31.7	33.0
655	4	40°46.8'	72°38.2'	0617	30	416	117.5	18	18	13.5	11.2	31.8	32.1
656	4	40°18.5'	72°19.5'	2130	30	70	28.6	7	55	16.5	5.4	31.9	33.1
657	4	40°16.0'	72°23.5'	2238	30	69	31.8	7	55	16.0	8.7	31.9	33.1
658	5	40°23.5'	72°55.0'	0216	30	222	56.2	9	41	15.0	5.7	31.4	33.0
659	5	40°21.0'	73°14.7'	0505	30	99	20.4	16	33	17.5	6.7	31.1	32.6
660	5	40°11.0'	73°17.2'	0720	30	56	15.0	14	37	16.6	6.0	31.2	33.1
661	5	40°03.8'	73°11.2'	0852	30	50	10.9	10	41	16.6	6.0	31.5	33.3
662	5	39°51.0'	73°13.5'	1055	30	329	20.0	9	46	16.7	6.0	31.6	33.3
663	5	39°58.5'	73°07.0'	1353	30	56	15.4	7	48	16.6	5.7	32.2	33.3
664	5	39°56.1'	72°50.8'	1556	30	18	4.5	4	54	16.7	5.8	32.4	33.3
665	5	40°01.6'	72°41.6'	1736	30	87	30.4	12	58	16.1	5.6	32.3	33.2
666	5	40°13.5'	72°43.5'	2035	30	312	122.0	10	54	15.7	5.3	31.8	33.1
667	5	40°09.8'	72°27.8'	2237	30	183	68.0	10	57	15.7	5.7	32.0	33.2
668	4	40°11.3'	72°13.6'	0111	30	122	48.5	10	68	15.4	5.8	32.7	33.3
669	6	39°44.3'	71°52.5'	1247	30	135	30.4	11	264	13.8	10.0	33.2	35.7
670	6	39°56.2'	71°50.5'	1618	30	149	25.4	11	113	16.9	12.1	34.5	35.3
671	6	39°54.5'	71°57.5'	1750	30	428	72.6	10	99	17.5	11.7	34.8	35.3
672	6	40°06.0'	71°55.6'	1946	30	245	82.1	11	77	14.3	12.0	32.8	33.9
673	6	39°58.9'	72°16.4'	2206	30	205	83.0	11	77	15.2	8.1	32.8	33.0
674	7	39°46.7'	72°27.5'	0133	30	358	97.1	10	75	16.3	7.7	32.6	33.7
675	7	39°36.0'	72°10.9'	0506	30	117	17.2	12	125	14.8	12.1	33.3	35.7
676	7	39°32.5'	72°22.0'	0723	30	29	3.2	9	210	15.3	9.0	33.5	35.4
677	7	39°16.0'	72°22.0'	1130	30	48	2.3	11	225	18.8	11.5	35.4	35.7
678	7	39°12.4'	72°40.3'	1654	30	93	19.1	11	127	17.4	11.2	33.3	35.2
679	7	39°26.5'	72°44.2'	1857	30	201	73.0	7	74	16.8	9.1	32.5	34.5
680	8	39°34.1'	72°47.6'	0006	30	119	49.4	7	66	17.0	5.8	32.4	33.3
681	8	39°41.3'	72°50.8'	0232	30	145	50.8	9	67	16.7	7.3	39.1	33.4
682	8	39°41.1'	73°11.2'	0646	30	26	19.1	6	43	16.6	7.2	31.2	32.8
683	8	39°45.2'	73°53.8'	1149	30	86	35.4	10	24	18.3	8.2	31.4	32.7
684	8	39°43.0'	74°02.0'	1318	30	98	61.7	11	17	17.4	9.1	30.2	32.4
685	8	39°58.6'	74°02.5'	1556	30	433	137.0	16	17	17.3	9.5	29.1	32.3
686	8	39°56.4'	73°38.5'	1915	30	120	19.5	11	31	15.8	7.7	31.4	32.7
687	8	40°04.5'	73°50.7'	2102	30	347	73.5	19	24	**	**	31.3	32.5
688	8	40°00.5'	73°54.0'	2235	30	511	136.1	18	21	16.4	8.4	31.1	32.5
689	9	40°05.3'	74°00.8'	0010	30	630	161.5	16	20	16.8	11.0	28.4	31.3
690	9	40°10.7'	73°57.0'	0145	30	1014	238.1	16	17	16.7	10.5	30.4	32.3
691	9	40°12.0'	73°49.9'	0338	30	220	104.8	15	27	16.7	8.4	31.2	32.4
692	9	40°13.7'	73°45.8'	0527	30	296	146.1	19	63	16.2	6.4	31.3	33.0
693	9	40°11.7'	73°43.9'	0706	30	410	157.9	16	57	16.0	6.3	33.0	31.2
694	9	40°12.4'	73°37.0'	0837	30	299	134.7	17	71	15.6	6.0	31.3	33.2
695	9	40°08.5'	73°30.5'	1116	30	73	28.1	14	38	15.9	6.6	31.1	32.8
696	9	40°15.6'	73°34.5'	1251	30	76	32.7	11	26	15.9	8.4	31.3	32.4
697	9	40°17.0'	73°38.0'	1403	30	67	29.0	15	24	16.5	8.1	30.9	31.2
698	9	40°18.0'	73°42.8'	1509	30	41	33.1	11	28	16.5	8.8	31.0	32.2
699	9	40°15.8'	73°50.7'	1640	30	193	117.0	14	25	16.9	8.7	31.3	32.5
700	9	40°23.6'	73°57.1'	1834	30	393	167.8	16	12	16.7	12.5	27.0	27.3

Table 3.--List of fishes collected in New York Bight, June 1974 to June 1975, arranged according to Bailey et al. (1970), including number and weight by station of occurrence; i.e., station number (number of fish; weight in kg). An asterisk (*) indicates a weight of less than 0.5 kg.

MYXINIDAE

Myxine glutinosa, Atlantic hagfish

100(8; 0.5)   101(1; *)   163(1; *)   286(2; *)   289(5; 0.5)   346(1; *)
417(3; *)   440(1; *)   458(3; 0.5)

LAMNIDAE

Carcharodon carcharias, white shark

138(1; 23.6)

SCYLIORHINIDAE

Scyliorhinus retifer, chain dogfish

348(1; 0.5)   414(1; *)   538(1; *)   604(1; 0.5)   610(8; 2.3)   612(2; 0.5)
670(5; 0.9)   675(1; *)   678(1; *)

CARCHARHINIDAE

Mustelus canis, smooth dogfish

19(5; 14.1)   20(3; 6.8)   21(3; 5.0)   23(4; 16.8)   24(10; 24.9)
27(2; 4.1)   28(2; 2.3)   30(2; 7.7)   37(8; 0.9)   45(4; 11.3)
46(2; 4.5)   47(4; 13.2)   48(7; 14.1)   49(5; 14.1)   50(6; 13.6)
52(8; 19.5)   53(4; 9.5)   61(9; 15.0)   65(12; 5.0)   66(5; 3.6)
68(2; 0.9)   71(2; 1.4)   72(2; 1.4)   77(31; 39.5)   78(1; 1.4)
79(5; 3.6)   80(4; 10.9)   81(1; 2.7)   82(3; 6.8)   83(4; 10.4)
84(32; 73.5)   85(14; 32.2)   88(1; 3.6)   89(1; 3.2)   90(1; 0.9)
91(3; 8.2)   92(1; 0.9)   116(3; 8.2)   117(2; 5.9)   118(1; 3.6)
120(2; 5.0)   123(3; 2.7)   137(130; 300.3)   138(27; 42.2)   140(1; 1.8)
141(2; 5.4)   142(8; 17.2)   143(2; 4.1)   144(10; 21.8)   145(5; 13.2)
146(3; 6.4)   148(13; 33.1)   150(5; 6.4)   151(33; 74.8)   162(1; *)
186(1; 1.4)   187(1; 0.9)   197(36; 85.3)   198(21; 50.8)   199(6; 15.0)
200(49; 123.4)   201(11; 36.7)   202(14; 44.5)   203(34; 100.2)   204(12; 31.8)
205(87; 268.1)   206(68; 4.5)   207(339; 90.7)   208(10; 14.1)   209(4; 6.4)
211(18; 54.9)   212(2; 4.1)   213(24; 74.8)   214(6; 20.0)   215(1; 1.4)
216(1; 1.8)   232(43; 129.7)   233(51; 94.3)   234(24; 60.3)   235(23; 63.0)
236(21; 64.9)   277(1; 2.3)   288(2; 0.5)   294(6; 15.0)   298(4; 13.6)
340(1; 0.5)   583(1; 1.4)   589(1; 4.1)   625(2; 3.6)   626(1; 1.4)
637(15; 19.5)   638(6; 15.4)   639(3; 3.2)   642(4; 12.7)   643(1; 1.8)
644(5; 10.4)   645(2; 3.2)   646(12; 29.5)   647(3; 7.7)   648(4; 16.8)
649(9; 20.4)   650(4; 5.4)   651(11; 31.3)   653(13; 30.4)   655(3; 3.6)
659(1; 2.7)   678(1; *)   683(1; 2.7)   684(10; 26.8)   685(6; 12.2)
686(2; 4.1)   687(1; 2.7)   688(2; 4.1)   689(1; 2.3)   691(3; 6.4)
693(1; 1.8)   695(1; 2.3)   696(3; 7.3)   697(2; 5.0)   698(4; 16.3)
699(9; 22.7)   700(17; 30.4)

SQUALIDAE

Squalus acanthias, spiny dogfish

18(3; 14.5)   20(4; 18.6)   21(3; 13.2)   22(1; 5.0)
23(3; 7.3)   24(7; 24.9)   25(8; 32.2)   27(2; 8.6)
30(4; 13.6)   44(1; 4.1)   47(3; 13.6)   49(1; 2.3)
50(4; 19.1)   51(6; 23.1)   52(11; 44.0)   53(8; 30.8)
54(1; 5.0)   55(1; 4.1)   59(3; 12.2)   60(3; 12.2)
259(121; 230.9)   260(208; 385.1)   261(154; 447.2)   262(16; 49.9)
263(28; 85.3)   264(283; 698.5)   265(138; 410.5)   266(168; 538.0)

Squalus acanthias--Cont.

267(96; 248.1)   268(105; 212.7)   269(106; 215.0)   270(5; 15.4)
271(56; 162.8)   272(2; 7.3)   273(29; 69.9)   274(107; 363.8)
275(22; 50.3)   276(216; 857.3)   277(161; 492.1)   278(102; 290.3)
279(332; 957.5)   280(2; 5.0)   281(11; 20.9)   282(12; 23.1)
283(6; 13.6)   284(2; 5.9)   291(18; 31.3)   292(14; 49.0)
293(324; 851.8)   294(3; 9.5)   295(490; 1151.2)   296(26; 73.0)
297(339; 900.8)   298(3; 7.3)   321(2; 3.2)   323(5; 11.3)
324(3; 5.4)   326(1; 1.4)   327(2; 4.1)   328(35; 111.6)
329(23; 58.5)   330(11; 23.6)   331(7; 15.4)   332(7; 15.4)
333(2; 5.4)   334(4; 12.2)   335(134; 192.8)   336(35; 95.3)
337(71; 102.5)   338(4; 11.8)   340(1; 4.5)   341(41; 114.3)
342(86; 275.6)   343(38; 298.9)   346(6; 11.3)   348(4; 4.5)
349(207; 414.1)   350(23; 57.2)   351(29; 83.0)   352(110; 412.8)
353(37; 136.5)   354(25; 38.6)   356(28; 58.5)   357(178; 38.6)
397(1; 4.1)   398(3; 8.2)   406(5; 14.5)   407(3; 11.3)
408(184; 213.2)   409(116; 171.9)   410(231; 88.0)   413(9; 10.9)
414(48; 47.2)   415(71; 108.9)   416(131; 78.0)   417(3; 8.2)
421(51; 83.0)   422(197; 200.0)   423(188; 485.8)   424(302; 339.3)
425(14; 33.6)   430(1; 3.6)   432(14; 27.7)   433(4; 15.0)
434(3; 11.8)   435(1; 4.1)   440(9; 7.3)   441(5; 2.7)
442(37; 16.8)   443(5; 14.5)   444(38; 61.7)   445(4; 5.4)
446(2; 6.4)   447(118; 249.9)   448(165; 100.7)   449(2; 2.7)
450(3; 1.8)   451(3; 1.4)   452(579; 1264.2)   453(250; 412.8)
454(28; 63.0)   455(51; 120.7)   456(344; 753.0)   457(78; 127.5)
458(11; 15.9)   472(1; 3.6)   473(1; 3.6)   476(2; 7.3)
481(1; 3.2)   513(13; 38.6)   515(45; 146.1)   516(4; 11.3)
518(1; 3.2)   519(3; 10.0)   524(3; 10.4)   525(3; 12.7)
527(23; 76.7)   528(33; 89.4)   529(129; 345.6)   530(42; 115.7)
531(4; 3.6)   532(2; 2.3)   533(8; 31.3)   534(14; 43.1)
535(66; 152.0)   536(3; 4.5)   540(5; 10.9)   541(49; 154.7)
542(31; 94.3)   543(39; 80.3)   544(56; 170.6)   545(27; 70.3)
546(2; 6.8)   572(4; 14.1)   573(1; 4.1)   574(3; 11.3)
575(20; 88.5)   576(6; 25.9)   578(3; 11.3)   579(1; 3.6)
581(13; 54.0)   582(3; 7.3)   583(10; 37.2)   584(21; 77.1)
585(3; 5.9)   586(5; 5.9)   587(8; 31.8)   588(19; 82.6)
589(19; 72.6)   590(18; 64.9)   591(27; 106.6)   593(1; 3.2)
594(5; 15.0)   595(2; 9.1)   596(3; 8.2)   597(2; 2.7)
598(2; 6.8)   599(3; 7.3)   601(2; 6.8)   602(4; 10.9)
603(1; *)   605(7; 1.8)   608(7; 4.5)   609(76; 8.2)
611(1; 0.9)   612(1; *)   615(2; 5.5)   616(17; 13.2)
617(6; 21.8)   618(3; 5.4)   619(25; 9.5)   620(5; 15.4)
621(1; 4.1)   622(21; 88.9)   623(2; 8.6)   624(8; 30.4)
625(1; 4.1)   626(1; 6.4)   627(8; 31.3)   638(7; 29.5)
639(1; 3.2)   640(3; 12.2)   641(7; 25.9)   642(2; 9.1)
643(6; 23.6)   644(38; 84.4)   645(1; 5.0)   646(1; 5.0)
647(5; 18.1)   648(15; 58.5)   649(1; 4.1)   651(26; 101.2)
653(25; 104.3)   671(2; 0.5)   672(7; 4.1)   674(16; 1.8)
678(1; *)   681(1; *)   688(1; 5.4)   690(4; 17.2)
691(7; 30.4)   698(1; 3.6)   699(6; 26.8)   700(6; 28.6)

TORPEDINIDAE

Torpedo nobiliana, Atlantic torpedo

23(1; 8.6)   61(2; *)

RAJIDAE

Raja eglanteria, clearnose skate

111(1; 1.4) 138(1; 1.4) 143(3; 1.4) 150(7; 3.6) 198(3; 2.7) 205(1; 1.8)
206(2; 3.2) 232(1; 1.8)

Raja erinacea, little skate

19(1; 0.5) 25(5; 2.3) 22(2; 0.9) 28(2; 0.5) 29(2; 0.9)
30(2; 0.9) 31(1; 0.5) 41(2; 0.9) 42(3; 1.4) 43(2; 0.9)
44(5; 1.8) 45(7; 3.2) 46(9; 3.2) 54(1; 0.5) 56(11; 4.5)
57(13; 4.5) 58(15; 5.0) 59(20; 6.4) 60(8; 3.2) 70(106; 50.8)
81(4; 1.8) 82(86; 31.8) 83(59; 28.1) 84(12; 6.4) 85(27; 14.5)
86(393; 125.2) 87(59; 22.7) 88(2; 0.9) 89(10; 5.0) 90(15; 9.5)
91(9; 4.5) 92(91; 45.8) 93(64; 14.1) 94(6; 2.7) 95(1; 0.5)
96(3; 1.4) 98(1; 0.5) 104(6; 2.3) 105(187; 72.1) 106(14; 5.4)
107(365; 105.7) 108(15; 5.4) 110(7; 3.6) 112(108; 32.2) 113(20; 5.9)
114(6; 2.3) 115(235; 98.4) 116(177; 73.0) 117(39; 17.7) 118(19; 8.2)
119(32; 10.4) 120(29; 13.6) 140(1; 0.5) 141(26; 12.7) 142(18; 10.0)
145(48; 17.7) 146(44; 12.7) 147(23; 10.0) 148(5; 2.3) 149(27; 12.7)
151(17; 10.4) 152(125; 47.6) 153(208; 76.2) 154(11; 4.5) 155(140; 50.8)
156(28; 10.9) 157(36; 19.1) 158(13; 6.4) 159(3; 1.4) 160(156; 88.0)
161(14; 5.9) 167(46; 12.7) 168(10; 3.6) 170(1; *) 171(1; 0.5)
172(15; 0.9) 173(1; *) 174(35; 10.4) 175(116; 42.6) 176(16; 5.9)
177(27; 10.0) 178(5; 1.4) 179(3; 1.4) 198(1; 0.5) 200(8; 4.1)
201(19; 8.6) 202(5; 1.8) 203(11; 5.9) 204(5; 2.7) 205(5; 4.5)
206(5; 1.8) 207(3; 1.4) 208(9; 4.1) 209(1; 0.5) 210(4; 2.3)
211(61; 32.2) 212(2; 0.5) 213(115; 65.3) 214(95; 49.4) 215(64; 42.6)
216(45; 18.1) 217(1; *) 223(46; 23.1) 224(107; 35.8) 225(82; 29.0)
226(282; 127.0) 227(105; 44.9) 228(61; 30.8) 229(101; 38.1) 230(35; 14.5)
231(26; 10.0) 236(25; 10.9) 260(9; 4.5) 261(4; 1.8) 262(3; 1.4)
263(14; 7.7) 264(22; 12.2) 265(5; 2.3) 266(17; 9.1) 267(74; 30.8)
268(35; 15.9) 269(9; 4.5) 270(5; 2.3) 271(4; 1.8) 272(28; 17.2)
273(52; 27.2) 274(47; 20.0) 275(19; 10.0) 276(116; 53.1) 277(258; 100.7)
278(88; 45.8) 279(35; 16.3) 280(189; 60.8) 281(94; 44.9) 282(24; 11.8)
283(44; 24.0) 284(3; 0.9) 285(6; 4.1) 291(100; 61.7) 292(123; 112.0)
293(118; 48.5) 294(69; 30.4) 295(20; 24.5) 296(66; 29.0) 297(41; 20.0)
298(8; 5.0) 321(15; 7.3) 322(14; 8.6) 323(31; 16.3) 324(149; 64.9)
325(152; 82.1) 326(142; 63.0) 327(134; 64.0) 328(47; 25.9) 329(12; 5.4)
330(346; 122.0) 331(43; 22.2) 332(192; 66.2) 333(213; 79.8) 334(193; 79.4)
335(83; 39.0) 336(42; 23.1) 337(47; 23.1) 338(128; 76.2) 339(151; 81.2)
340(126; 70.8) 341(112; 32.2) 342(808; 249.0) 343(207; 88.9) 349(51; 31.8)
350(68; 39.5) 351(36; 19.5) 352(1; 0.5) 353(21; 7.3) 354(8; 3.6)
356(62; 24.9) 357(139; 73.0) 389(19; 8.6) 390(24; 12.7) 391(15; 7.3)
392(20; 11.3) 393(96; 34.0) 394(41; 15.4) 395(37; 14.1) 396(172; 56.7)
397(174; 80.7) 398(172; 71.2) 399(30; 8.2) 400(15; 7.3) 401(45; 26.3)
402(5; 1.8) 403(24; 11.3) 404(165; 57.2) 405(168; 49.9) 406(116; 39.5)
407(60; 29.5) 408(22; 12.2) 409(33; 19.1) 410(46; 24.5) 413(3; 1.8)
414(54; 29.0) 415(111; 51.7) 416(72; 33.1) 417(8; 3.6) 421(112; 40.8)
422(131; 61.2) 423(48; 25.4) 424(7; 4.1) 425(18; 8.6) 426(16; 5.4)
427(66; 25.4) 428(93; 34.5) 429(90; 31.8) 430(44; 17.7) 431(52; 21.8)
432(40; 15.4) 433(262; 75.3) 434(196; 51.7) 435(101; 33.1) 436(22; 6.8)
437(542; 170.1) 438(74; 25.9) 439(1; 0.5) 443(24; 6.4) 444(35; 14.5)
445(21; 9.1) 446(1; 0.5) 447(1; 0.9) 452(73; 20.0) 453(11; 4.1)
454(4; 1.8) 455(14; 7.3) 456(17; 9.1) 457(26; 20.4) 458(3; 0.5)
459(5; 2.3) 460(27; 13.2) 461(48; 18.1) 462(40; 14.1) 463(33; 10.0)
464(55; 19.1) 465(7; 4.5) 466(4; 1.8) 467(14; 6.4) 470(22; 9.1)

Table 3.--Continued

Raja erinacea--Cont.
471(9; 4.1) 472(11; 5.0) 473(8; 3.6) 474(11; 5.0) 475(40; 13.6)
476(15; 5.9) 477(8; 2.7) 478(50; 14.5) 479(57; 20.0) 480(40; 12.2)
481(30; 8.2) 482(33; 12.7) 483(15; 3.2) 484(55; 29.5) 485(5; 3.2)
501(4; 1.8) 502(48; 23.6) 503(40; 16.8) 504(76; 24.5) 505(79; 21.3)
506(55; 19.5) 507(81; 20.9) 508(95; 36.7) 509(17; 6.4) 510(30; 14.5)
511(48; 24.0) 512(19; 8.6) 513(46; 20.4) 515(75; 36.7) 516(9; 4.5)
517(2; 0.5) 518(1; 0.5) 520(2; 0.9) 521(2; 8.2) 522(41; 14.1)
523(63; 15.0) 524(18; 5.4) 525(12; 5.9) 526(6; 2.7) 527(12; 5.9)
528(62; 27.7) 529(28; 10.4) 530(9; 4.1) 534(7; 5.0) 535(33; 18.6)
540(12; 7.7) 541(77; 38.6) 542(14; 8.6) 543(49; 21.3) 544(50; 25.9)
545(38; 20.0) 546(2; 0.9) 547(9; 3.2) 568(18; 9.1) 569(13; 6.8)
570(63; 26.8) 571(19; 8.2) 572(29; 11.3) 573(94; 40.4) 574(55; 16.8)
575(51; 21.3) 576(75; 25.9) 577(37; 11.8) 578(36; 13.6) 579(29; 12.2)
580(41; 14.1) 581(23; 8.6) 582(52; 17.7) 583(94; 29.0) 584(170; 60.3)
585(198; 68.5) 586(105; 34.0) 587(47; 20.4) 588(82; 28.6) 589(336; 111.6)
590(225; 69.4) 591(32; 11.8) 592(268; 50.3) 593(71; 66.7) 594(175; 70.3)
595(185; 72.6) 596(73; 120.7) 597(91; 48.1) 598(9; 5.0) 599(28; 13.6)
600(184; 64.0) 601(293; 122.0) 602(63; 23.1) 603(51; 29.0) 606(2; 1.4)
607(9; 6.8) 608(36; 20.4) 609(5; 3.6) 614(14; 9.5) 615(80; 48.5)
616(71; 37.6) 617(9; 4.5) 618(10; 5.4) 619(198; 88.0) 620(24; 10.9)
621(238; 70.3) 622(246; 83.5) 623(226; 76.2) 624(75; 34.0) 625(57; 23.6)
626(13; 6.4) 627(8; 3.2) 637(7; 3.6) 638(23; 11.8) 639(2; 0.5)
640(17; 7.3) 641(73; 25.9) 642(68; 25.9) 643(59; 25.9) 644(19; 9.1)
645(7; 2.7) 646(4; 1.8) 647(23; 9.1) 648(17; 6.4) 649(7; 1.8)
650(30; 14.5) 651(23; 8.2) 652(32; 16.3) 653(340; 146.5) 654(54; 24.5)
655(82; 27.2) 656(34; 15.9) 657(41; 17.2) 658(82; 32.2) 659(18; 7.7)
660(19; 9.1) 661(14; 6.4) 662(9; 5.4) 663(27; 11.8) 664(8; 4.1)
665(41; 17.7) 666(205; 84.4) 667(136; 55.8) 668(77; 33.6) 669(5; 1.8)
671(3; 1.8) 672(14; 9.5) 673(34; 19.1) 674(29; 16.8) 679(14; 8.6)
680(56; 24.9) 681(83; 41.3) 682(9; 3.6) 683(31; 10.4) 684(26; 12.2)
685(40; 20.0) 686(17; 5.4) 687(101; 37.2) 688(153; 64.0) 689(103; 48.1)
690(66; 27.2) 691(60; 24.0) 692(76; 28.1) 693(273; 5.0) 694(74; 49.9)
695(33; 14.1) 696(35; 12.7) 697(27; 12.2) 698(6; 1.8) 699(100; 40.8)
700(21; 10.0)

Raja garmani, rosette skate
101(1; 0.5) 165(2; 0.9) 219(1; 0.5) 288(1; *) 290(1; *) 347(3; 0.9)
411(1; 0.5) 418(2; 0.9) 450(1; 0.5) 539(1; 0.5) 604(6; 1.4) 610(8; 2.7)
613(1; *) 675(2; 0.5) 676(1; 0.5) 678(6; 1.8) 680(1; *)

Raja laevis, barndoor skate
346(2; 15.0)

Raja ocellata, winter skate
228(1; 1.8) 233(9; 12.7) 234(1; 6.4) 259(1; *) 325(6; 24.5)
326(2; 15.0) 327(1; 2.3) 330(1; 5.9) 331(3; 10.9) 332(2; 9.1)
333(13; 46.3) 335(1; 1.8) 342(1; 1.8) 354(1; 5.4) 356(1; 1.4)
390(8; 18.1) 391(3; 5.9) 392(5; 6.4) 393(3; 12.7) 395(3; 5.9)
397(3; 10.9) 399(1; 1.4) 400(3; 8.2) 401(10; 42.2) 402(6; 20.9)
404(3; 5.4) 405(3; 10.9) 432(1; 6.4) 438(1; 3.6) 454(2; 17.2)

Table 3.--Continued

Raja ocellata--Cont.
461(1; 2.3) 462(1; 2.7) 465(1; 1.4) 480(1; 1.4) 481(1; 5.4)
482(2; 4.1) 484(2; 7.7) 502(2; 5.9) 503(1; 2.3) 504(1; 3.6)
505(1; 2.7) 506(1; 4.1) 508(1; 5.4) 511(1; 2.7) 512(2; 6.4)
513(1; 6.8) 515(1; 5.4) 521(3; 9.1) 524(1; *) 525(1; 2.7)
527(1; 4.5) 545(1; 7.7) 568(3; 13.2) 569(2; 6.8) 570(3; 9.1)
575(1; 5.0) 578(1; 5.0) 579(1; 5.0) 581(1; 3.2) 582(1; 1.8)
583(2; 5.4) 584(4; 21.8) 586(1; 3.6) 588(1; 4.1) 589(3; 6.8)
590(1; 5.4) 591(1; 3.2) 592(8; 33.1) 593(6; 23.1) 594(3; 8.6)
621(1; 1.8) 622(1; 5.4) 623(1; 5.0) 637(3; 5.9) 639(1; 2.3)
650(2; 5.4) 651(1; 2.3) 665(1; 5.0) 688(1; 0.5) 692(1; 2.3)
693(1; 2.3)

Raja radiata, thorny skate
286(4; 0.9) 348(17; 6.8) 417(8; 31.8) 537(2; 0.9) 538(1; *) 612(5; 0.9)
655(1; *)

DASYATIDAE
Dasyatis centroura, roughtail stingray
137(1; 7.7) 203(2; 38.1) 204(1; 15.4) 205(1; 17.7) 209(1; 15.4)

ACIPENSERIDAE
Acipenser oxyrhynchus, Atlantic sturgeon
651(1; 5.9)

ANGUILLIDAE
Anguilla rostrata, American eel
327(1; 0.5) 357(1; *)

SIMENCHELYIDAE
Simenchelys parasiticus, snubnose eel (See: Leim and Scott 1966)
422(1; *)

CONGRIDAE
Conger oceanicus, conger eel
204(1; *) 215(1; *) 286(1; *) 319(1; *) 324(1; *) 353(1; *)
487(1; 0.5) 558(1; *) 560(1; 0.5) 570(1; *) 572(1; *) 670(2; 1.8)

OPHICHTHIDAE
Pisodonophis cruentifer, snake eel (See: Rosenblatt and McCosker 1970)
33(2; *) 104(6; *) 106(3; *) 115(1; *) 152(2; *) 155(1; *)
158(1; *) 160(4; *) 161(2; *) 164(2; *) 168(2; *) 217(1; *)
218(1; *) 224(7; *) 225(3; *) 226(4; *) 227(4; *) 228(1; *)
291(1; *) 293(1; *) 325(1; *) 338(3; *) 340(4; *) 341(3; *)
347(2; *) 348(1; *) 410(1; *) 420(1; *) 451(1; *) 615(1; *)

NEMICHTHYIDAE
Nemichthys scolopaceus, slender snipe eel
417(1; *) 608(1; *) 609(1; *) 612(5; *)

CLUPEIDAE

Alosa aestivalis, blueback herring

16(300; 2.3) 17(140; 0.9) 18(1032; 6.8) 27(2; *) 28(7; 0.5)
29(5; 0.9) 50(1; *) 53(3; *) 61(53; 0.9) 150(2; *)
256(1; *) 258(29; 0.5) 300(6; *) 301(5; *) 302(1; *)
306(3; *) 308(1; *) 309(1; *) 313(9; *) 314(3; *)
315(9; *) 318(138; 5.9) 319(264; 7.3) 320(80; 15.4) 358(1; *)
359(19; 0.9) 360(1; *) 361(2; *) 362(1; *) 364(10; *)
365(41; 0.5) 366(26; 0.5) 367(22; 0.5) 368(8; *) 371(25; *)
373(67; 0.5) 374(26; *) 375(31; *) 376(1; *) 379(1; *)
381(15; 0.5) 385(15; *) 386(2; 0.5) 392(2; *) 393(33; 5.4)
399(25; 0.5) 400(102; 0.9) 401(2; *) 402(1; *) 454(1; *)
484(1; *) 488(2; *) 493(31; 0.9) 494(7; *) 495(2; *)
496(97; 0.9) 497(70; 0.5) 500(43; 0.5) 509(1; *) 522(1; *)
546(13; 1.4) 547(1; *) 550(4; *) 552(3; *) 553(3; *)
554(35; *) 555(2; *) 556(10; *) 557(2; *) 561(1; *)
564(10; *) 565(9; 1.8) 566(9; 1.8) 568(8; 0.9) 577(1; *)
580(1; *) 590(3; *) 593(1; *) 628(1; *) 629(1; *)
630(1; *) 632(1; *) 633(2; *) 638(3; *) 641(3; 0.5)
655(22; 1.4) 659(7; 0.9) 692(4; 0.5) 693(2; *) 694(21; 4.1)

Alosa mediocris, hickory shad

17(2; 0.5)

Alosa pseudoharengus, alewife

16(40; 0.9) 17(328; 42.6) 19(1; *) 20(1; *) 21(1; *)
28(1; *) 48(1; *) 53(163; 4.5) 61(1; *) 70(3; *)
238(4; *) 246(2; *) 249(1; *) 256(9; 0.5) 257(8; 0.5)
258(1; *) 282(1; 0.5) 299(24; 0.9) 300(34; 0.9) 301(2; *)
306(140; 1.8) 309(1; *) 311(28; 1.4) 313(8; *) 314(7; *)
315(4; *) 317(1; *) 320(4; *) 322(7; *) 325(2; *)
326(1; *) 358(23; 0.9) 361(6; *) 362(1; *) 363(3; *)
364(21; 0.5) 365(20; 0.5) 366(19; 0.5) 367(3; *) 368(12; *)
369(9; *) 370(3; *) 371(21; 0.5) 372(23; 0.5) 373(18; 0.5)
374(189; 9.5) 375(111; 2.7) 376(1; *) 379(20; *) 383(1; *)
384(13; *) 385(1; *) 386(1634; 15.9) 387(281; 3.2) 388(1203; 10.0)
389(42; 5.0) 390(23; 1.8) 391(12; 1.8) 392(16; 3.2) 393(17; 2.3)
394(10; 1.8) 395(5; *) 396(14; 2.3) 397(2; *) 399(122; 10.9)
400(213; 12.7) 401(56; 4.1) 402(113; 7.7) 403(36; 6.8) 405(6; 0.9)
429(3; 0.5) 430(17; 3.2) 431(1; *) 433(16; 4.1) 434(20; 5.4)
435(1; *) 436(377; 82.6) 437(3; 0.5) 438(4; 0.5) 440(6; 0.9)
443(4; 1.4) 445(3; 0.9) 447(1; 0.5) 455(2; 0.9) 459(13; 1.4)
463(1; *) 466(1; *) 471(1; *) 472(1; *) 473(1; *)
483(2; 0.5) 484(4; 0.5) 485(1; *) 486(3; 0.9) 487(2; 0.5)
488(1; *) 490(1; *) 493(17; 0.9) 494(2; *) 496(4; *)
497(1; *) 500(10; *) 501(1; 0.5) 509(18; 1.8) 510(3; 0.5)
511(13; 1.4) 515(1; *) 518(22; 1.4) 519(2; *) 522(1; *)
524(3; 0.5) 527(2; 0.5) 528(1; *) 529(1; 0.5) 542(15; 4.1)
543(18; 3.2) 544(1; *) 546(35; 2.7) 547(1; *) 556(10; *)
557(3; *) 558(3; *) 559(1; *) 560(2; *) 561(2; *)
564(6; *) 565(15; 0.9) 566(22; 1.4) 567(16; 0.9) 568(64; 4.5)
569(135; 13.6) 570(28; 1.8) 571(29; 4.1) 577(312; 23.6) 578(207; 17.2)
579(17; 0.9) 580(15; 1.8) 581(1; *) 583(2; 0.5) 589(4; 0.9)
590(24; 4.5) 591(1; *) 592(30; 1.8) 593(19; 2.3) 594(21; 3.6)

Alosa pseudoharengus--Cont.				
598(1; *)	606(2; *)	608(6; 0.9)	615(1; *)	616(1; *)
618(1; *)	624(1; *)	625(1; *)	626(4; 0.5)	627(9; 1.4)
638(8; 0.9)	640(2; *)	641(2; *)	650(21; 1.8)	655(19; 1.4)
694(10; 1.8)				
Alosa sapidissima, American shad				
2(1; *)	16(7; *)	17(6; 0.5)	28(1; *)	29(3; *)
53(16; 0.5)	54(4; 3.6)	256(1; *)	299(6; *)	300(6; *)
301(24; 0.5)	302(1; *)	306(10; *)	309(7; *)	310(3; *)
312(1; *)	314(2; *)	315(1; *)	316(1; *)	318(10; *)
319(23; *)	320(70; 1.8)	358(5; *)	359(2; *)	361(5; *)
363(15; *)	364(25; 0.5)	365(50; 0.5)	366(80; 0.9)	367(6; *)
368(6; *)	369(13; *)	371(4; *)	372(7; *)	373(2; *)
374(56; 0.9)	375(12; *)	379(1; *)	386(48; 0.9)	387(33; 0.5)
388(117; 1.4)	390(10; *)	393(3; *)	396(2; *)	399(3; 0.9)
400(3; 0.5)	401(5; 0.5)	402(3; *)	426(1; *)	436(11; 7.7)
440(7; 1.8)	511(2; *)	542(3; 1.8)	553(2; *)	554(1; *)
555(2; *)	556(8; *)	557(1; *)	558(2; *)	559(6; *)
560(1; *)	564(2; *)	566(2; *)	567(1; 0.5)	568(1; *)
570(4; 0.5)	571(1; *)	577(5; 0.5)	580(4; 0.5)	588(1; 0.5)
589(8; 0.9)	590(7; 0.9)	591(1; 0.9)	592(31; 0.9)	593(1; *)
611(3; 0.9)	612(1; 0.5)	619(1; 0.5)	625(1; *)	626(4; *)
638(6; 0.5)	641(1; *)	642(1; *)	650(1; *)	655(7; *)
694(1; 0.9)				
Brevoortia tyrannus, Atlantic menhaden				
2(1; *)	3(1; *)	8(2; *)	9(4; 0.5)	10(1; *)
14(2; 0.5)	16(4; 0.5)	17(36; 7.3)	18(2; 0.5)	69(1; *)
237(2; *)	250(1; *)	256(15; 0.5)	258(1; *)	299(4; 0.9)
300(6; 0.5)	301(1; 0.5)	311(2; 0.5)	313(3; 0.5)	314(1; *)
315(3; *)	318(11; 3.2)	319(1; *)	320(2; *)	322(3; 0.9)
363(2; *)	364(1; *)	366(7; *)	369(2; *)	371(1; *)
372(5; 0.5)	373(1; *)	374(246; 1.4)	375(15; 0.5)	379(4; *)
381(1; *)	382(2; *)	386(27; 0.5)	387(2; *)	497(1; *)
549(4; 0.9)	550(1; *)	554(2; *)	555(1; *)	556(1; *)
628(1; *)	629(4; 0.9)	630(1; 1.4)	631(7; 0.9)	632(1; *)
633(2; *)				
Clupea harengus harengus, Atlantic herring				
7(1; *)	14(4; 0.5)	17(70; 19.1)	358(5; 1.4)	359(3; 0.9)
362(3; 0.9)	364(10; 3.2)	365(1; 0.5)	366(3; 0.9)	369(1; 0.5)
370(1; 0.5)	371(1; 0.5)	373(2; 0.5)	374(2; 0.5)	375(24; 6.4)
376(2; 0.5)	377(1; 0.5)	379(1; *)	381(6; 1.4)	383(9; 2.7)
385(2; *)	387(8; 1.8)	388(15; 3.6)	399(2; 0.5)	400(4; 0.9)
401(1; *)	403(2; *)	461(1; *)	476(1; 0.5)	491(3; 0.9)
492(1; *)	493(1; 0.5)	495(1; *)	500(2; 0.5)	506(3; 0.5)
507(1; *)	509(3; 0.5)	513(5; 0.9)	518(2; 0.5)	546(1; *)
554(5; 0.9)	555(1; *)	568(1; *)	569(4; 1.4)	571(1; 0.5)
572(1; 0.5)	574(3; 0.5)	575(6; 1.4)	576(6; 1.8)	577(4; 0.9)
578(19; 5.0)	581(6; 1.8)	582(2; 0.5)	583(2; 0.5)	584(4; 1.4)
585(5; 1.4)	587(8; 2.3)	588(4; 0.9)	590(3; *)	591(3; 0.9)
599(2; 0.5)	618(4; 1.4)	619(2; 0.5)	631(1; *)	

Table 3.--Continued

Etrumeus teres, round herring
84(1; *)   109(7; *)   111(11; *)   120(6; *)   137(2; *)
139(1484; 25.4)   140(140; 2.3)   142(1; *)   147(612; 10.9)   148(29; 0.5)
150(2070; 20.9)   151(23; 0.5)   169(33; 0.9)   171(1; *)   172(1; *)
176(644; 25.4)   181(3; *)   197(76; 1.4)   198(1682; 13.2)   199(204; 19.5)
209(1995; 25.9)   210(81; 1.4)   211(28; 0.5)   215(4; *)   216(2; *)
228(1060; 24.0)   229(1; *)   259(98; 1.8)   268(1; *)   269(12; *)
270(2187; 36.7)   276(2; *)   278(31; 0.5)   279(26; *)   297(2; *)
298(8; *)   324(1; *)   329(13; *)   357(1; *)

ENGRAULIDAE
Anchoa hepsetus, striped anchovy
136(1; *)   322(3; *)   332(2; *)   333(10; *)   390(2; *)   566(2; *)
580(92; 0.5)

Anchoa mitchilli, bay anchovy
9(1; *)   11(1; *)   14(1; *)   16(104; 0.5)
17(2080; 9.1)   18(1152; 6.8)   61(792; 2.3)   67(1; *)
68(1; *)   73(2; *)   74(1; *)   75(7; *)
77(2; *)   78(164; 0.9)   79(840; 3.2)   92(1; *)
123(2; *)   124(35; *)   126(31; *)   128(67; 0.5)
130(17; *)   131(13; *)   133(1; *)   136(98; 0.5)
150(1; *)   182(152; 0.9)   183(29; *)   184(592; 2.3)
186(1; *)   187(192; 1.4)   188(980; 6.4)   189(1428; 4.1)
190(228; 1.4)   191(17; *)   192(144; *)   193(44; *)
194(1768; 7.7)   214(2; *)   215(10920; 33.6)   232(1; *)
239(4680; 1.4)   256(2046; 10.0)   258(15364; 20.9)   272(136; *)
273(184; *)   275(3; *)   298(5088; 10.9)   300(8; *)
302(26; *)   303(4; *)   307(1; *)   308(8; *)
309(22; *)   310(28; *)   313(4; *)   314(31; *)
315(20; *)   316(4; *)   317(2; *)   318(30; 0.5)
319(30; 0.5)   320(208; 0.5)   323(1; *)   325(3; *)
326(3; *)   358(1; *)   499(1; *)   570(890; 9.1)
581(9; *)   639(1; *)   641(1; *)   689(15; *)
700(1; *)

Engraulis eurystole, silver anchovy
125(2; *)   140(4; *)   147(369; 5.0)   148(1; *)
150(555; 6.8)   151(6; *)   195(152; 0.5)   196(30307; 41.7)
198(396; 4.1)   209(27; 0.5)   210(7752; 30.8)   211(5; *)
212(768; 1.8)   214(3; *)   237(312; 1.4)   238(504; 1.4)
240(280; *)   241(12; *)   245(480; *)   246(2; *)
247(16; *)   248(23; *)   249(50; *)   250(3; *)
251(64; *)   252(20; *)   253(10; *)   257(5200; 11.3)
259(2; *)   260(3; *)   270(344; 3.6)   565(1; *)
568(788; 2.3)

ARGENTINIDAE
Argentina silus, Atlantic argentine
36(1; *)   162(116; 0.9)   347(7; *)   348(9; *)   532(1; *)
538(1; *)   539(4; *)   604(7; *)   605(4; *)   613(3; *)
676(4; *)   677(1; *)

Table 3.--Continued

GONOSTOMATIDAE
Gonostoma elongatum, longtooth anglemouth (See: Leim and Scott 1966)
99(13; *)   289(2; *)   420(2; *)   458(2; *)

Maurolicus muelleri, Muller's pearlsides (See: Leim and Scott 1966)
163(2; *)   449(9; *)   538(1; *)   605(20; *)

CHAULIODONTIDAE
Chauliodus sloani, viperfish (See: Leim and Scott 1966)
99(1; *)

SYNODONTIDAE
Synodus foetens, inshore lizardfish
199(1; *)   208(3; *)   209(1; *)   215(4; *)   232(3; *)   238(1; *)
278(1; *)   294(1; *)   298(2; *)   329(1; *)   335(1; *)   352(1; *)
357(1; *)

Synodus sp.
268(1; *)   269(1; *)   275(1; *)

Trachinocephalus myops, snakefish
199(3; *)   212(8; *)   261(7; *)   262(2; *)   270(3; *)   272(1; *)
273(1; *)

CHLOROPHTHALMIDAE
Chlorophthalmus agassizi, shortnose greeneye
36(7; *)   39(3; *)   99(2; *)   163(7; *)   164(33; 0.5)
218(31; *)   221(126; 0.9)   286(2; *)   289(2; *)   420(7; *)
441(1; *)   449(1; *)   458(3; *)   531(9; *)   538(6; *)
539(1; *)   604(1; *)   605(3; *)   611(13; *)   669(1; *)
676(2; *)   677(7; *)

MYCTOPHIDAE
Myctophid, unidentifiable to genus

35(2; *)   36(1; *)   39(21; *)   99(2; *)   164(42; *)
218(152; 0.5)   221(128; *)   344(4; 0.5)   347(12; *)   420(4; *)
440(23; *)   441(10; *)   450(11; *)   451(20; *)   531(1; *)
537(1; *)   539(1; *)   613(1; *)

STERNOPTYCHIDAE
Argyropelecus aculeatus, Atlantic silver hatchfish (See: Leim and Scott 1966)
39(4; *)   100(4; *)   221(1; *)   289(3; *)   441(1; *)   458(1; *)

LOPHIDAE
Lophius americanus, goosefish
19(3; 23.1)   20(1; 3.2)   21(1; 2.7)   22(2; 7.7)   23(2; 5.4)
27(1; 10.0)   28(3; 24.5)   29(2; 12.7)   30(1; 1.8)   31(1; 12.2)
32(2; 1.8)   34(1; 0.9)   38(1; 6.4)   39(3; 8.2)   47(1; 3.6)
48(2; 11.8)   50(2; 11.3)   54(3; 14.5)   56(3; 8.6)   57(1; 0.5)
58(1; 3.6)   59(2; 0.9)   60(1; 0.5)   86(4; 4.1)   87(6; 15.0)
94(3; 4.1)   95(1; 12.7)   96(1; 0.9)   99(12; 28.1)   100(3; 4.1)
101(2; 2.3)   102(1; 8.2)   104(2; 1.8)   105(5; 1.4)   107(1; 1.4)
112(1; 7.7)   114(1; 5.0)   115(3; 2.3)   116(2; 9.1)   117(1; 0.5)

Table 3.--Continued

Lophius americanus--Cont.

152(18; 36.3) 153(16; 27.2) 154(1; 1.4) 155(2; 1.8) 157(1; 5.0)
158(2; 0.9) 160(11; 36.7) 161(2; 7.7) 162(6; 20.0) 163(2; 0.9)
164(9; 0.5) 165(1; 3.6) 166(1; 1.8) 167(6; 5.4) 175(1; *)
178(1; 0.5) 210(1; 13.6) 215(1; 6.4) 217(8; 20.0) 218(1; 7.7)
219(1; 5.0) 220(2; 4.5) 221(8; 9.5) 222(1; 1.8) 223(3; 2.3)
224(7; 17.7) 225(4; 7.3) 226(6; 15.0) 227(1; 2.3) 228(16; 25.9)
231(1; 9.5) 259(1; 8.2) 260(2; 19.1) 261(1; *) 262(2; 23.1)
265(1; 7.3) 266(1; 4.1) 271(1; 14.5) 272(1; 11.8) 273(1; 4.5)
274(2; 18.6) 277(2; 19.1) 278(2; 16.3) 279(3; 25.4) 280(5; 4.1)
281(4; 10.4) 282(1; 1.8) 283(2; 6.8) 285(5; 13.2) 286(17; 29.0)
287(1; 5.0) 288(2; 2.3) 289(8; 5.9) 290(7; 2.7) 291(4; 6.8)
292(6; 17.7) 294(1; 7.7) 296(2; 1.4) 298(2; 16.3) 318(1; 10.4)
322(2; 21.8) 323(3; 34.9) 325(2; 21.3) 326(5; 30.4) 327(7; 76.7)
329(1; 7.7) 330(2; 15.9) 331(6; 38.1) 332(12; 100.2) 333(32; 243.6)
334(3; 14.5) 336(4; 15.0) 337(6; 8.6) 338(27; 39.5) 339(12; 22.7)
340(25; 44.9) 342(3; 9.5) 343(46; 50.8) 344(4; 5.0) 346(18; 24.5)
347(1; 0.5) 348(1; 0.9) 349(1; *) 350(1; *) 353(2; 10.9)
354(2; 29.0) 391(1; 14.1) 392(3; 31.3) 393(1; 0.9) 394(2; 8.6)
395(1; 1.4) 396(4; 9.1) 397(2; 13.6) 398(4; 13.2) 401(1; 12.2)
402(1; 9.1) 403(1; 10.9) 404(1; 4.5) 405(3; 18.1) 407(3; 5.0)
408(2; 7.7) 410(4; 8.2) 411(8; 5.9) 413(2; 2.3) 414(5; 9.5)
415(3; 7.3) 416(8; 15.4) 417(4; 9.5) 420(9; 6.8) 421(1; 0.9)
422(8; 10.4) 424(20; 37.6) 425(2; 2.7) 427(2; 11.8) 428(2; 13.2)
430(1; 9.1) 432(1; 6.8) 433(3; 9.5) 434(1; *) 437(8; 19.5)
440(2; 2.7) 441(2; 18.1) 442(5; 14.1) 443(1; 3.2) 444(1; 1.4)
445(2; 4.1) 446(3; 2.7) 447(4; 5.4) 448(1; 0.9) 450(1; 1.4)
452(1; 1.8) 453(1; 1.8) 455(2; 3.6) 458(10; 10.9) 467(1; 10.9)
478(1; 6.8) 504(2; 30.4) 505(1; 5.0) 507(1; *) 510(1; 9.1)
512(1; 3.2) 522(1; 5.9) 525(1; 2.7) 528(3; 3.2) 529(2; 3.6)
531(2; 6.4) 532(1; 2.3) 533(3; 4.5) 534(4; 5.4) 535(2; 3.2)
537(4; 11.3) 538(3; 18.1) 540(1; 1.4) 542(3; 4.5) 545(4; 15.4)
546(1; 1.8) 568(4; 31.8) 569(3; 24.0) 570(2; 6.4) 571(5; 26.3)
572(2; 10.9) 574(2; 6.4) 575(2; 1.4) 576(7; 18.1) 577(5; 48.1)
578(4; 30.8) 579(1; 10.4) 580(1; 10.9) 581(2; 15.4) 582(1; 3.2)
583(2; 1.8) 584(2; 16.8) 585(2; 9.5) 586(2; 4.5) 587(1; 1.4)
588(2; 19.5) 589(9; 100.7) 590(1; 14.1) 592(4; 44.9) 593(1; 8.6)
594(1; 11.3) 595(3; 4.5) 596(1; 0.9) 597(3; 6.8) 598(2; 5.0)
599(1; 2.3) 601(6; 23.6) 602(1; *) 603(10; 11.8) 604(4; 21.3)
605(5; 27.2) 606(3; 6.4) 607(1; 2.3) 608(4; 3.6) 609(6; 7.7)
611(1; 4.1) 612(8; 37.6) 613(1; *) 615(5; 10.4) 616(5; 8.2)
617(1; 3.2) 618(2; 2.7) 619(2; 2.3) 621(1; *) 622(1; 9.5)
623(4; 24.0) 624(1; 13.6) 625(2; 20.0) 626(2; 18.6) 638(1; 5.4)
640(1; 5.4) 641(4; 13.6) 642(1; 8.2) 643(7; 21.8) 644(2; 11.3)
645(3; 13.2) 646(3; 16.8) 647(2; 5.9) 648(2; 7.7) 649(2; 15.4)
650(6; 42.2) 651(5; 22.7) 652(5; 20.4) 653(2; 12.7) 654(1; 11.3)
655(2; 18.1) 657(3; 9.5) 658(1; 10.0) 659(1; 0.9) 660(2; 2.7)
661(2; 0.9) 662(1; *) 663(1; 0.5) 666(10; 26.8) 667(4; 8.6)
668(5; 8.6) 669(2; 5.4) 670(1; 10.0) 671(2; 1.8) 672(3; 1.4)
673(13; 33.6) 674(6; 13.2) 675(1; 4.1) 676(1; 0.5) 678(3; 6.4)
679(4; 11.3) 680(5; 10.4) 681(2; 2.7) 682(2; 13.6) 683(2; 14.1)
684(2; 10.0) 685(4; 20.4) 688(2; 8.2) 689(3; 18.6) 690(1; 5.0)
691(2; 8.6) 692(18; 2.7) 693(5; 35.4) 694(4; 34.0) 695(1; 7.3)
696(2; 10.4) 697(1; 5.4) 698(1; 7.7) 699(2; 8.2) 700(1; 15.4)

Table 3.--Continued

OGCOCEPHALIDAE
Dibranchus atlanticus, Atlantic batfish (See: Leim and Scott 1966)
99(7; *) 101(2; *) 164(4; *) 289(1; *) 290(1; *) 420(2; *)
458(1; *) 612(2; *)

GADIDAE
Enchelyopus cimbrius, fourbeard rockling
36(1; *) 163(2; *) 164(2; *) 175(1; *) 179(1; *) 228(1; *)
289(1; *) 296(9; 0.5) 346(1; *) 576(4; 0.5) 612(2; *) 667(1; *)
693(1; *)

Gadus morhua, Atlantic cod
324(3; 18.1) 327(2; 11.3) 330(1; 1.8) 331(2; 7.3) 334(1; 3.6)
337(1; 9.5) 341(5; 17.7) 352(7; 30.8) 353(2; 7.3) 354(2; 5.4)
356(5; 13.6) 390(2; 4.5) 391(3; 8.2) 392(8; 19.1) 393(4; 11.8)
394(2; 5.4) 395(2; 5.9) 396(7; 22.2) 397(9; 32.2) 398(3; 14.5)
399(1; 2.7) 400(1; 2.3) 401(9; 34.5) 402(9; 27.7) 403(6; 20.4)
404(3; 10.9) 405(4; 14.1) 406(1; 4.5) 425(1; 4.5) 426(1; 3.6)
427(2; 8.2) 430(3; 10.9) 431(3; 10.0) 432(2; 5.0) 433(2; 5.4)
434(5; 14.1) 435(1; 2.7) 436(1; 3.6) 437(1; 11.8) 443(1; 15.0)
445(1; 4.1) 446(2; 5.9) 459(2; 8.2) 460(4; 14.5) 461(1; 5.4)
462(2; 7.3) 463(1; 5.0) 464(2; 5.4) 474(3; 18.1) 475(1; 4.5)
476(1; 5.9) 477(1; 5.4) 479(4; 14.1) 480(3; 8.6) 481(1; 2.3)
482(1; 2.3) 484(13; 41.3) 485(1; 3.2) 502(4; 10.0) 503(1; 2.3)
504(1; 2.3) 506(4; 8.2) 507(1; 2.3) 508(4; 10.0) 510(4; 20.4)
511(2; 7.7) 512(8; 18.1) 515(39; 9.5) 519(1; 5.9) 521(2; 8.6)
522(1; 6.8) 525(4; 24.9) 527(1; 5.4) 546(4; 6.4) 572(2; 5.9)
585(1; 2.3) 586(1; 3.6) 587(10; *) 588(2; 5.0) 591(1; 6.8)
594(2; *) 595(1; 6.4) 598(1; *) 600(2; 10.0) 602(1; 4.5)
616(1; *) 623(1; 5.4) 652(2; *) 654(1; *) 655(1; 1.8)
659(2; *) 660(2; *) 661(2; *) 665(2; *) 687(2; *)

Melanogrammus aeglefinus, haddock
98(1; *) 591(1; *)

Merluccius albidus, offshore hake (See: Leim and Scott 1966)
36(2; *) 39(2; 0.5) 99(58; 23.6) 100(17; 2.3) 103(1; *)
163(81; 10.4) 164(85; 12.2) 167(42; 1.8) 218(14; 2.3) 219(32; *)
221(70; 10.9) 286(157; 39.5) 288(4; 0.9) 289(58; 10.9) 344(91; 23.1)
346(8; 3.2) 347(13; 0.9) 412(17; 2.7) 420(37; 10.0) 441(5; 4.1)
450(4; 0.9) 451(4; 0.9) 458(7; 1.4) 531(29; 12.2) 537(14; 3.2)
538(9; 2.7) 571(2; 0.9) 605(14; 5.0) 611(300; 53.1) 612(99; 39.9)
613(1; *) 669(22; 8.2) 672(1; 1.4) 676(9; 1.4) 677(1; *)

Merluccius bilinearis, silver hake
17(69; 3.2) 19(576; 12.2) 20(462; 9.5) 21(280; 6.4)
22(4; *) 24(25; 0.5) 28(397; 5.0) 29(754; 15.9)
30(2; 0.5) 31(7; 1.4) 32(8; 3.2) 34(2; 0.9)
36(2; *) 37(5; 0.9) 39(6; 1.4) 41(7; 1.8)
42(5; 0.5) 43(5; *) 44(6; *) 45(43; 0.5)
46(68; 1.4) 47(4; *) 48(79; 0.9) 49(19; 0.9)
50(2; *) 51(9; *) 52(41; 1.4) 53(76; 1.4)
54(15; 1.4) 55(14; *) 57(3; *) 58(30; 0.5)
59(4; 0.5) 60(17; 0.5) 80(11; 0.5) 83(2; *)

Merluccius bilinearis--Cont.

84(2; *) 87(16; 5.4) 90(3; *) 92(1; *)
93(1; *) 94(24; 3.6) 95(7; 0.5) 96(5; 0.5)
97(1; *) 98(11; 1.4) 104(2; 0.5) 105(5; 0.9)
106(3; *) 107(27; 1.4) 109(1; *) 111(1; *)
112(132; 6.4) 115(15; 0.9) 116(8; 0.5) 118(1; *)
119(11; 0.5) 120(14; 0.5) 141(9; *) 142(19;*)
143(1; *) 144(12; *) 145(10; *) 149(2; *)
150(1; *) 152(6; 0.5) 153(6; 0.5) 155(4; *)
157(31; 1.4) 158(4; 0.9) 159(2; 0.5) 160(19; 1.4)
161(16; *) 162(25; *) 166(1; 0.5) 168(2; *)
174(7; 0.5) 175(468; 20.4) 176(2; *) 178(2; *)
179(37; 1.4) 180(16; *) 197(2; *) 198(2; *)
200(2; *) 201(23; *) 202(15; *) 203(6; *)
204(27; *) 206(35; *) 207(1; *) 208(4; *)
209(98; 0.5) 210(1; *) 212(608; 1.8) 214(10; *)
215(243; 2.3) 216(1; *) 217(10; *) 223(3; 0.5)
224(7; 1.4) 225(5; *) 226(4; 0.9) 227(3; *)
228(1907; 110.7) 229(11; 0.5) 230(1; *) 232(1; *)
233(1; *) 234(33; 0.5) 259(44; 1.8) 260(219; 1.4)
261(21; *) 262(51; 0.5) 263(98; *) 264(21; *)
265(16; *) 266(2; *) 270(13; *) 271(52; *)
272(234; 1.4) 273(112; *) 274(184; *) 275(11; *)
276(6; *) 277(68; *) 278(3; *) 279(4; *)
280(4; 0.9) 281(1; *) 282(10; 1.4) 283(8; 1.8)
284(5; 0.5) 285(5; 0.5) 290(17; 0.9) 292(7; 3.2)
293(6; *) 294(3; *) 295(1; *) 296(8; 2.3)
297(2; *) 298(5; *) 299(14; *) 300(10; *)
301(2; *) 303(1; *) 305(2; *) 306(46; *)
308(8; *) 310(1; *) 311(1; *) 312(3; *)
316(10; *) 317(1; *) 318(27; *) 319(41; *)
320(5; *) 321(299; 1.4) 322(148; 1.8) 323(85; 1.4)
324(28; 0.9) 325(270; 2.3) 326(37; *) 327(58; 0.5)
329(11; 2.3) 330(130; 17.2) 331(257; 4.1) 332(28; 0.5)
333(29; 2.7) 334(28; 0.9) 335(2; 1.8) 337(1; *)
338(3; 0.5) 340(4; 0.9) 341(3; 0.9) 342(2; *)
349(2; 0.5) 350(1; *) 352(8; 1.4) 353(4; 0.9)
354(3; *) 356(5; 0.5) 359(1; *) 361(9; 0.5)
362(1; *) 371(2; *) 374(5; *) 379(1; *)
383(1; *) 386(15; 0.5) 387(28; *) 388(3; *)
389(34; 7.7) 390(34; 6.8) 391(58; 10.0) 392(80; 5.4)
393(77; 3.2) 394(99; 7.7) 395(55; 6.4) 396(95; 10.4)
397(42; 4.1) 398(71; 5.0) 399(136; 18.1) 400(125; 14.1)
401(198; 21.3) 402(138; 5.4) 403(72; 2.7) 404(79; 14.5)
405(42; 3.2) 406(182; 5.0) 407(4; 0.9) 408(1; 0.5)
409(9; 1.8) 410(15; 2.7) 411(6; 1.4) 413(18; 5.4)
414(7; 1.4) 415(36; 12.7) 416(18; 5.0) 417(17; 2.7)
420(3; *) 421(6; 1.8) 422(31; 7.3) 423(5; 2.3)
424(71; 19.1) 426(22; 3.2) 427(91; 3.6) 428(33; 3.6)
429(30; 4.5) 430(72; 10.0) 431(59; 8.6) 432(46; 12.7)
433(134; 10.0) 434(113; 11.3) 435(101; 13.2) 436(43; 14.5)
437(91; 19.5) 438(37; 9.5) 439(11; 2.7) 440(122; 29.5)
441(110; 29.5) 442(108; 20.0) 443(159; 15.0) 444(51; 7.7)
445(303; 54.9) 446(13; 1.8) 447(33; 10.9) 448(56; 14.1)
449(2; 0.5) 450(6; 1.4) 451(1; *) 452(85; 19.1)

Merluccius bilinearis--Cont.

453(79; 16.3) 454(277; 43.5) 455(177; 41.7) 456(100; 24.5)
457(33; 12.7) 458(9; 3.6) 459(44; 10.0) 460(127; 25.9)
461(5; 0.9) 462(1; *) 463(17; 2.3) 464(6; 2.7)
465(4; 0.5) 466(13; 3.6) 467(12; 2.3) 470(24; 6.4)
471(34; 10.0) 472(1; *) 473(6; 0.9) 474(16; 3.6)
475(6; 1.4) 476(2; 0.5) 477(3; 0.5) 478(1; *)
479(16; 2.3) 480(5; 2.7) 481(8; 0.9) 482(2; *)
483(5; *) 484(2; 0.5) 485(5; 0.9) 486(6; 1.8)
487(1; *) 488(1; *) 489(3; 0.9) 499(1; *)
501(26; 8.6) 502(21; 4.1) 503(43; 8.6) 504(37; 11.3)
505(19; 2.3) 506(17; 5.4) 507(13; 1.8) 508(7; 0.5)
509(2; 0.5) 510(1; *) 511(2; 0.9) 512(17; 0.5)
513(15; 2.3) 516(5; *) 517(2; 0.5) 518(7; 1.8)
519(1; 0.5) 521(17; 1.4) 522(55; 18.6) 523(7; 1.4)
524(3; 0.5) 525(3; 4.1) 526(2; 1.4) 527(36; 8.2)
528(8; 3.2) 529(4; 0.5) 530(2; 0.5) 531(26; 6.4)
533(2; 0.5) 534(1; *) 535(32; 18.1) 538(12; 2.3)
539(2; 0.5) 540(12; 3.2) 541(38; 8.2) 542(1; 1.8)
543(24; 6.4) 544(25; 7.7) 545(99; 34.9) 546(4; 0.9)
547(7; 7.7) 550(5; 1.4) 551(1; *) 555(1; *)
556(1; *) 557(6; 1.8) 558(33; 6.8) 559(4; *)
560(10; 2.7) 561(8; 2.3) 562(12; 3.2) 563(6; 2.3)
564(2; *) 565(7; 1.4) 566(17; 3.6) 567(121; 29.5)
568(14; 2.7) 569(28; 3.6) 570(187; 28.1) 571(93; 13.6)
572(16; 6.8) 573(7; 1.8) 574(6; 1.4) 575(5; 0.5)
576(14; 2.7) 577(10; 1.4) 578(16; 5.0) 579(29; 6.4)
580(41; 8.2) 581(328; 28.1) 582(169; 26.8) 583(168; 15.4)
584(31; 6.8) 585(21; 1.8) 586(4; 0.9) 587(12; 0.9)
588(53; 6.8) 589(153; 33.1) 590(190; 33.1) 591(24; 4.5)
592(59; 54.0) 593(334; 70.8) 594(175; 36.3) 595(58; 27.2)
596(6; 1.8) 597(10; 3.2) 598(10; 2.3) 599(16; 3.6)
600(37; 10.4) 601(21; 4.1) 602(16; 4.1) 603(23; 6.4)
604(13; 4.5) 605(81; 15.4) 606(6; 1.4) 607(5; 1.4)
608(16; 4.1) 609(17; 8.6) 610(21; 4.5) 613(6; 0.9)
614(7; 3.2) 615(21; 4.5) 616(36; 7.3) 618(8; 3.2)
619(35; 9.1) 620(10; 2.7) 621(34; 0.5) 622(36; 7.3)
623(11; 2.3) 624(3; 1.4) 625(23; 1.4) 626(69; 24.5)
627(3; 1.4) 638(2; *) 640(29; 0.5) 641(25; 1.8)
642(32; *) 643(2; *) 645(29; *) 646(5; *)
648(1; *) 649(36; 0.9) 650(26; *) 651(50; 0.9)
652(4; *) 653(179; 7.7) 654(6; 0.5) 655(23; 1.8)
656(5; 0.5) 657(3; 0.5) 659(21; 0.5) 660(2; *)
661(4; *) 663(5; 0.5) 664(5; 0.5) 665(5; 0.9)
666(2; 0.5) 667(4; 0.5) 668(4; 0.5) 669(5; 0.9)
670(4; 0.5) 671(30; 9.1) 672(16; 4.1) 673(5; 1.4)
674(9; 2.7) 675(1; 0.5) 678(6; 1.8) 679(12; 2.7)
680(11; 3.2) 681(8; 1.8) 682(5; 0.5) 683(3; *)
684(1; *) 685(62; 0.9) 686(26; 0.5) 687(59; 0.9)
688(14; *) 690(3; *) 691(10; 0.9) 692(18; 2.7)
693(22; 2.3) 694(57; 14.5) 695(3; *) 696(20; *)
697(7; *) 698(10; *) 699(11; 0.9) 700(2; *)

Microgadus tomcod, Atlantic tomcod
570(1; *)

Phycis chesteri, longfin hake
39(3; *) 99(4; 0.5) 163(19; *) 164(50; 1.4) 221(1; *) 286(52; 5.0)
346(1; *) 417(4; *) 537(56; 2.3) 612(79; 5.0)

Physiculus fulvus, hakeling (See: Bigelow and Schroeder 1953)
163(2; *) 537(1; *)

Pollachius virens, pollock
415(1; 0.9) 444(1; 13.2) 529(1; 13.2) 659(1; *) 660(1; *) 665(3; *)

Urophycis chuss, red hake
14(1; *) 17(42; 2.3) 19(3; *) 21(5; *) 22(1; *)
28(2; *) 29(2; 0.5) 31(2; 0.5) 32(13; 4.1) 36(66; 5.4)
39(16; 4.5) 43(3; *) 44(3; *) 45(1; *) 46(3; *)
49(1; *) 54(7; 1.8) 58(13; 0.5) 59(2; 0.5) 60(11; *)
68(1; *) 71(1; *) 72(1; *) 77(2; *) 79(1; *)
80(1; *) 85(1; *) 87(180; 52.6) 90(7; *) 92(2; *)
93(20; *) 94(41; 6.4) 96(2; *) 99(128; 2.3) 100(13; 1.4)
104(19; 0.5) 105(756; 36.3) 106(4; 0.5) 107(64; 6.8) 111(6; *)
112(2; *) 113(2; *) 114(2; *) 117(5; *) 141(30; 1.4)
142(93; *) 143(6; *) 144(16; *) 145(72; *) 146(4; *)
150(2; *) 152(132; 14.5) 153(85; 9.5) 154(2; 0.5) 155(60; 8.6)
156(3; *) 157(7; 1.4) 159(4; *) 160(81; 7.7) 161(1; *)
163(42; 4.5) 164(5; 0.9) 167(176; 11.8) 168(4; *) 174(3; 0.5)
175(2; *) 176(34; *) 178(18; *) 179(35; *) 180(9; 0.5)
181(11; 0.9) 198(2; *) 199(1; *) 200(19; *) 201(2; *)
202(14; *) 203(3; *) 204(29; *) 205(2; *) 206(7; *)
211(2; *) 212(112; 0.5) 214(17; *) 215(9; *) 216(1; *)
217(1; *) 218(13; 0.9) 223(339; 37.6) 224(91; 6.4) 225(31; 5.0)
226(60; 5.0) 227(3; *) 228(141; 27.2) 229(4; 0.5) 233(20; *)
234(27; 0.5) 235(29; *) 236(10; *) 254(1; *) 260(18; *)
261(11; *) 262(42; *) 263(31; *) 264(13; *) 265(39; *)
266(4; *) 267(1; *) 268(1; *) 269(1; *) 270(1; *)
271(10; *) 272(65; 0.9) 273(74; 0.9) 274(20; *) 275(44; 0.5)
276(5; *) 277(25; *) 278(1; *) 279(1; *) 280(10; *)
281(20; *) 282(3; *) 283(1; *) 285(4; *) 289(15; 1.8)
292(1; *) 293(100; *) 294(11; *) 295(34; *) 296(18; 4.5)
299(1; *) 300(1; *) 302(2; *) 306(3; *) 310(1; *)
311(4; *) 318(4; *) 320(1; *) 321(30; *) 322(26; *)
323(34; *) 324(37; *) 325(163; 23.1) 326(1426; 20.9) 327(1482; 34.0)
329(1; *) 331(144; 2.7) 332(1038; 20.9) 333(1284; 27.2) 334(364; 9.5)
335(2; *) 336(1; 0.9) 338(15; 0.5) 339(5; *) 340(2; *)
341(7; *) 342(1; *) 344(96; 8.6) 346(362; 58.1) 347(5; 1.4)
348(45; *) 350(4; *) 351(1; *) 353(13; *) 354(7; 0.9)
356(23; 0.9) 357(2; 0.9) 361(8; *) 373(1; *) 375(1; *)
376(1; *) 386(6; 0.5) 387(7; *) 388(5; *) 389(61; 4.5)
390(35; *) 391(90; 3.2) 392(293; 2.3) 393(152; 1.4) 394(176; 3.6)
395(312; 3.6) 396(308; 10.0) 397(73; 0.5) 398(27; 0.5) 399(33; 1.8)
400(20; 0.5) 401(78; 1.4) 403(8; 0.5) 404(162; 1.4) 405(180; 3.2)
406(2; 0.9) 408(3; *) 409(1; 0.5) 410(51; 15.4) 412(1; 0.5)
413(8; 4.1) 414(10; 3.6) 415(68; 25.4) 416(22; 5.4) 417(6; 1.4)
420(56; 5.4) 422(64; 17.2) 424(348; 133.4) 426(7; *) 427(62; 0.5)
428(229; 15.4) 429(188; 12.7) 430(34; 0.9) 431(37; 3.2) 432(5; 1.8)
433(9; *) 434(1; 0.5) 435(33; 9.1) 436(12; 2.3) 437(141; 16.3)
438(54; 2.3) 439(47; 3.2) 440(5; 1.4) 441(135; 23.6) 442(31; 10.4)
443(1; *) 444(7; 3.2) 447(104; 27.7) 448(5; 2.3) 451(1; *)
452(32; 11.8) 453(29; 7.7) 454(1; 0.9) 455(18; 8.2) 456(10; 4.5)
458(34; 4.5) 459(4; *) 460(19; *) 461(110; 0.9) 462(48; 0.5)

Urophycis chuss--Cont.

463(47; 0.9)	464(19; *)	466(20; 1.4)	467(5; *)	470(27; 1.4)
471(12; 1.4)	473(1; *)	474(23; 2.7)	475(16; 1.4)	476(4; *)
477(22; 1.4)	478(12; *)	479(55; 0.9)	480(119; 1.4)	481(5; *)
482(2; *)	483(12; *)	484(33; 0.5)	485(1; *)	486(9; 0.5)
487(5; *)	489(1; *)	494(1; *)	501(85; 5.0)	502(50; 0.5)
503(116; 2.7)	504(105; 2.7)	505(93; 1.4)	506(12; *)	507(49; 0.5)
508(4; *)	509(2; *)	510(7; *)	511(42; 0.5)	512(7; *)
513(14; *)	515(38; 11.3)	517(20; 3.6)	518(31; 1.8)	521(58; 0.5)
522(102; 27.7)	523(52; 0.9)	525(11; 6.4)	526(3; 2.3)	528(7; 2.7)
529(3; 1.4)	530(3; 1.4)	531(8; 1.8)	534(2; 0.9)	535(60; 18.1)
540(2; 0.9)	541(11; 4.1)	542(7; 3.2)	543(4; 1.8)	544(40; 10.9)
545(7; 0.9)	546(5; *)	547(5; 1.8)	549(2; *)	550(3; *)
551(12; 1.4)	552(2; *)	555(4; *)	557(39; 1.8)	558(116; 7.7)
559(24; 0.9)	560(25; 1.8)	561(23; 5.0)	562(34; 5.4)	563(106; 13.2)
564(50; 5.0)	565(133; 9.1)	566(147; 9.1)	567(214; 25.4)	568(5; 1.4)
569(12; 0.5)	570(145; 31.3)	571(134; 20.9)	572(563; 7.7)	573(266; 8.2)
574(326; 5.4)	575(372; 37.6)	576(353; 23.1)	577(16; 0.9)	578(13; 4.5)
579(92; 9.5)	580(69; 12.2)	581(24; 1.4)	582(45; 4.1)	583(393; 8.6)
584(116; 3.2)	585(87; 1.8)	586(82; 9.5)	587(1; 0.9)	589(260; 27.7)
590(33; 0.5)	592(109; 15.4)	593(66; 8.6)	594(8; *)	595(97; 0.9)
596(14; *)	597(8; *)	599(1; *)	600(23; 0.5)	601(488; 184.2)
602(1; *)	603(125; 33.1)	604(6; 1.4)	605(18; 2.3)	608(6; 0.9)
609(6; 2.3)	613(30; 4.1)	614(4; 1.4)	615(48; 16.3)	616(56; 15.4)
618(2; 1.8)	619(308; 88.9)	620(4; 0.5)	621(113; 2.3)	622(83; 5.9)
623(66; 0.5)	624(13; *)	625(10; 0.5)	626(204; 50.8)	631(4; *)
636(21; *)	639(4; *)	640(12; *)	641(100; 3.6)	642(83; 2.3)
643(12; *)	644(5; *)	645(1; *)	649(2; *)	650(4; 0.5)
652(17; 0.5)	654(1; *)	656(5; *)	657(6; *)	658(23; 0.5)
659(10; *)	660(16; 0.5)	661(9; 1.8)	663(14; 0.9)	664(2; *)
665(5; 0.5)	666(41; 0.9)	667(17; 0.5)	668(5; 0.5)	669(33; 8.6)
671(91; 27.2)	672(145; 58.1)	673(79; 23.6)	674(224; 59.0)	679(140; 46.3)
680(33; 9.5)	681(15; 2.7)	684(1; *)	685(1; *)	686(7; 0.5)
687(41; 2.3)	688(36; 0.5)	689(39; 1.4)	690(3; *)	691(7; *)
692(106; 18.1)	693(41; 3.6)	694(66; 15.4)	695(7; 0.5)	696(4; *)
697(3; *)	698(5; *)	699(2; 0.5)	700(2; 0.9)	

Urophycis regius, spotted hake

9(2; *)	17(3; *)	19(1; *)	28(7; *)	34(7; 2.3)
37(5; 0.9)	43(3; *)	44(21; *)	45(35; *)	46(576; 1.8)
47(5; *)	53(1; *)	77(1; *)	80(12; 0.5)	82(1; *)
83(8; 0.5)	84(55; 1.4)	85(37; 1.4)	86(5; *)	87(31; 0.9)
90(3; *)	92(12; 0.5)	93(10; 0.5)	94(5; *)	96(1; 0.5)
97(7; 0.9)	100(8; 2.3)	103(12; 0.9)	104(4; 0.5)	106(2; 0.9)
107(3; *)	111(1; *)	112(7; 0.9)	113(2; *)	114(17; 0.5)
115(540; 24.5)	116(492; 16.3)	117(47; 1.8)	118(1; *)	119(3; *)
120(30; 0.9)	139(2; *)	141(24; 1.4)	142(20; 1.4)	143(22; 1.4)
144(12; 0.9)	145(2; *)	146(3; 0.5)	149(1; *)	150(2; *)
152(1; *)	153(2; 0.5)	154(1; *)	155(6; *)	156(1; *)
158(9; 0.9)	159(1; 0.5)	160(14; 1.8)	161(7; 1.4)	166(28; 2.7)
167(4; *)	168(33; 1.4)	172(1; *)	174(5; 0.5)	175(3; *)
176(5; 0.5)	177(20; 1.4)	178(55; 2.7)	179(113; 5.0)	180(46; 1.8)
181(1; *)	199(5; 0.5)	200(10; 0.9)	201(19; 1.4)	202(4; *)
203(2; *)	204(2; *)	211(2; *)	212(17; 1.8)	213(1; *)
214(1; *)	215(8; 1.4)	217(53; 5.0)	225(1; *)	227(37; 4.1)

Table 3.--Continued

Urophycis regius--Cont.
228(11; 0.9) 229(2; *) 230(1; *) 233(8; 0.5) 235(6; 0.5)
236(107; 8.6) 260(14; 1.4) 261(3; 0.5) 262(8; 0.9) 263(9; 1.4)
264(8; 0.9) 265(3; *) 266(1; 0.5) 268(2; *) 271(3; 0.5)
272(10; 1.8) 273(3; 0.5) 274(7; 0.9) 275(6; 0.5) 276(10; 1.4)
277(7; 0.9) 280(3; *) 281(3; 0.5) 285(1; *) 288(3; *)
289(2; *) 290(54; 5.4) 291(6; 0.5) 293(3; *) 294(173; 0.5)
295(10; 0.9) 296(2; *) 303(1; *) 306(14; *) 307(2; *)
308(1; *) 309(6; *) 310(4; *) 312(23; *) 314(1; *)
316(20; *) 318(2; *) 319(1; *) 320(3; *) 322(25; *)
323(17; *) 324(4; 0.9) 325(24; 14.1) 326(17; 5.0) 327(7; 1.8)
329(1; *) 330(2; *) 337(7; 1.4) 338(4; 0.5) 341(2; 0.5)
343(1; *) 344(4; 0.5) 346(5; 1.4) 347(13; 2.3) 348(1; *)
349(1; *) 353(5; 0.9) 354(6; *) 356(3; 0.5) 357(11; 1.4)
361(2; *) 386(7; 0.5) 387(4; *) 390(10; *) 392(1; *)
393(1; *) 394(1; *) 395(2; *) 410(3; 0.5) 413(2; 1.4)
415(1; *) 416(1; *) 421(1; 0.5) 422(3; 0.5) 426(3; *)
449(3; 0.9) 462(1; *) 474(1; *) 486(1; *) 492(1; *)
521(2; *) 533(5; 1.8) 539(1; 0.5) 556(18; *) 558(1; *)
559(2; *) 604(13; 3.2) 605(2; *) 609(1; *) 610(7; 2.3)
614(1; 0.5) 624(2; *) 625(5; *) 626(1; *) 628(1; *)
629(3; *) 631(1; *) 638(1; *) 639(12; *) 640(1; *)
645(1; *) 660(1; *) 670(5; 1.8) 671(1; 0.5) 675(2; 0.9)
678(13; 3.2) 685(4; *) 687(2; *) 688(1; *) 689(2; *)
690(4; *) 692(1; *)

Urophycis tenuis, white hake
156(3; 0.5) 157(35; 3.6) 286(5; 3.2) 296(1; *) 326(2; 1.8)
336(3; 0.9) 346(150; 40.4) 410(2; 3.2) 413(1; 0.5) 414(2; 3.2)
415(1; 8.6) 420(3; 1.8) 424(2; 2.3) 429(3; 0.9) 441(5; 8.2)
442(6; 2.7) 453(1; *) 458(2; 9.5) 531(1; 0.5) 535(1; 0.9)
537(1; 0.9) 577(2; 0.9) 605(4; 12.2) 606(4; 2.7) 607(2; 0.9)
611(10; 3.2) 612(3; 3.6) 626(2; 0.9) 628(2; *) 629(33; *)
630(20; *) 631(1; *) 669(3; 1.8) 687(1; *)

OPHIDIIDAE

Lepophidium cervinum, fawn cusk-eel
32(7; *) 33(11; *) 34(26; 0.5) 97(1; *) 98(4; *)
101(3; *) 104(4; *) 105(1; *) 158(1; *) 160(11; *)
161(90; 1.4) 162(124; 1.8) 167(5; *) 217(196; 3.2) 218(41; 0.9)
219(124; 0.9) 223(20; *) 274(1; *) 285(13; *) 290(5; *)
295(1; *) 322(1; *) 332(1; *) 338(4; *) 339(4; *)
340(18; 1.4) 343(2; *) 344(2; *) 347(6; *) 348(37; 0.5)
410(9; *) 416(2; *) 422(4; *) 449(27; 0.5) 450(32; 0.5)
451(8; *) 538(2; *) 540(1; *) 603(1; *) 605(3; *)
606(11; *) 607(3; *) 613(1; *) 615(5; *) 623(2; 0.5)
675(1; *) 689(1; *)

Rissola marginata, striped cusk-eel
144(3; 0.5) 212(5; *) 215(1; *) 233(1; *) 272(4; *) 283(1; *)
293(1; *) 325(1; *) 327(1; *) 334(2; *) 393(1; *) 410(1; *)
428(1; *) 430(1; *) 474(1; *) 521(1; *) 570(1; *)

Table 3.--Continued

ZOARCIDAE

Macrozoarces americanus, ocean pout
31(2; 0.9) 32(1; *) 51(1; 1.4) 57(1; 0.5) 58(1; *)
94(3; 0.5) 96(1; *) 105(4; 0.5) 107(25; 1.8) 112(6; 0.9)
152(5; *) 153(3; *) 154(1; *) 155(36; 4.1) 156(3; *)
157(7; 0.9) 158(1; *) 159(1; *) 167(4; *) 176(3; 0.5)
223(2; *) 224(5; 0.5) 225(2; *) 226(1; *) 227(2; *)
228(2; *) 229(53; 5.9) 230(1; *) 231(2; *) 236(1; 0.9)
281(2; *) 282(1; *) 291(1; *) 324(1; *) 336(7; 1.8)
337(2; *) 343(1; *) 389(2; 0.9) 391(1; *) 391(6; 1.8)
392(20; 6.8) 393(6; 3.2) 394(16; 5.4) 395(13; 6.8) 396(8; 5.0)
397(19; 12.7) 398(7; 7.3) 399(2; 1.4) 400(7; 6.4) 402(2; 1.4)
403(7; 5.0) 404(1; 0.9) 405(4; 4.5) 406(39; 30.8) 407(30; 17.2)
422(1; 0.5) 423(1; *) 427(5; 2.7) 429(2; 0.5) 430(3; 1.8)
431(6; 2.7) 433(1; 0.5) 434(4; 2.3) 435(45; 20.4) 436(15; 5.4)
437(51; 12.7) 438(4; 0.9) 439(5; 1.4) 443(6; 3.6) 444(1; *)
445(6; 5.0) 446(2; 2.3) 447(1; 0.5) 452(3; 2.3) 454(1; 0.5)
459(2; 1.4) 460(1; 0.5) 461(3; 0.5) 462(1; 0.9) 463(2; 1.8)
464(1; 0.5) 465(1; 0.5) 467(1; 0.5) 470(4; 1.8) 471(2; 1.4)
473(1; 0.5) 475(1; 0.5) 478(1; *) 479(8; 3.2) 480(1; 0.5)
483(2; 3.2) 484(1; 0.5) 485(1; 1.8) 501(34; 13.2) 502(6; 3.2)
503(1; 0.5) 504(1; *) 505(1; 0.5) 506(19; 16.3) 507(4; 4.5)
508(20; 25.9) 509(12; 13.2) 510(5; 5.4) 511(6; 5.0) 512(7; 10.9)
513(6; 6.4) 516(31; 32.2) 517(3; 1.4) 518(2; 0.9) 519(4; 2.7)
520(4; 2.3) 521(1; 0.5) 522(3; *) 523(1; *) 524(2; 2.3)
525(2; 2.3) 529(2; 1.8) 535(3; 1.8) 543(4; 4.1) 544(47; 8.6)
546(6; 4.1) 568(1; 0.5) 570(2; 0.5) 571(29; 14.5) 572(4; 2.7)
573(7; 2.7) 574(5; 2.7) 575(15; 10.9) 576(10; 4.1) 577(70; 52.6)
578(20; 17.7) 579(28; 12.2) 580(6; 2.3) 581(4; 1.8) 582(4; 2.7)
585(14; 11.3) 586(6; 5.9) 587(8; 7.3) 588(2; 1.4) 590(1; 1.8)
591(2; 1.4) 593(1; 0.9) 594(8; 7.3) 595(16; 16.8) 596(18; 17.2)
597(11; 8.2) 598(43; 37.2) 599(10; 9.1) 600(14; 14.1) 601(94; 50.8)
602(3; 1.4) 603(30; 15.9) 607(1; 0.9) 608(4; 3.2) 609(1; 1.4)
615(3; 2.3) 616(9; 5.0) 618(3; 1.4) 619(27; 10.0) 620(20; 12.7)
621(3; 1.4) 622(1; 0.9) 623(3; 3.2) 627(8; 9.1) 640(1; *)
642(1; *) 647(1; *) 654(1; *) 658(3; 0.9) 659(2; 0.5)
660(3; 0.9) 661(2; *) 665(2; *) 666(1; *) 667(1; *)
668(5; 1.8) 673(1; 0.5) 674(1; 0.9) 681(2; 0.5) 687(1; 0.5)
692(23; 8.2) 693(6; 0.9) 694(13; 3.6) 695(2; *) 696(1; *)
697(1; *) 699(5; 1.8)

Melanostigma atlanticum, Atlantic soft pout (See: Leim and Scott 1966)
221(4; *) 537(15; *) 538(1; *) 539(1; *)

MACROURIDAE

Coelorhynchus coelorhynchus carminatus, longnose grenadier (See: Marshall and Iwamoto 1973)
164(3; *) 221(12; *) 286(5; *) 357(2; *) 458(1; *) 612(11; *)

Ventrifossa occidentalis, American straptail grenadier (See: Marshall and Iwamoto 1973)
458(1; *)

Nezumia bairdi, marlin-spike
99(11; 0.9) 163(3; *) 164(8; 0.5) 286(6; *) 346(1; *) 417(25; 0.5)
537(16; 0.9) 611(13; 0.9) 612(3; *)

Table 3.--Continued

Macrourus berglax, roughhead grenadier (See: Marshall and Iwamoto 1973)
538(2; *) 612(14; *) 670(1; *)

Trachyhynchus murrayi, roughnose grenadier (See Leim and Scott 1966)
670(1; *)

Macrourid, unidentifiable to genus
289(3; *) 346(3; *) 531(6; *) 605(1; *) 669(3; 0.5)

EXOCOETIDAE
Hyporhamphus unifasciatus, halfbeak
226(1; *) 340(1; *)

ATHERINIDAE
Menidia menidia, Atlantic silverside
240(1; *) 250(6; *) 254(2; *) 256(1; *) 299(1; *)
301(24; *) 302(2; *) 303(7; *) 306(5; *) 307(1; *)
308(3; *) 309(2; *) 310(1; *) 312(1; *) 314(1; *)
316(1; *) 318(16; *) 319(7; *) 320(320; 1.8) 321(2; *)
325(1; *) 362(1; *) 364(3; *) 366(3; *) 387(2; *)
390(10; *) 391(8; *) 399(1; *) 402(7; *) 403(19; *)
474(1; *) 484(1; *) 509(2; *) 512(1; *) 517(1; *)
518(3; *) 519(3; *) 546(1; *) 549(1; *) 550(1; *)
553(28; *) 554(6; *) 555(12; *) 556(14; *) 560(1; *)
561(5; *) 562(1; *) 564(5; *) 628(78; *) 629(2; *)
633(12; *) 634(2; *) 635(9; *) 636(12; *)

POLYMIXIIDAE
Polymixia lowei, beardfish
164(1; *) 218(1; *) 344(4; *) 539(1; *) 677(1; *)

GASTEROSTEIDAE
Gasterosteus aculeatus, threespine stickleback
371(1; *) 511(1; *)

FISTULARIIDAE
Fistularia tabacaria, bluespotted cornetfish
172(1; *)

SYNGNATHIDAE
Hippocampus erectus, lined seahorse
35(1; *) 150(1; *) 195(1; *) 197(1; *) 208(2; *)
209(1; *) 210(1; *) 212(1; *) 215(2; *) 250(1; *)
251(1; *) 255(1; *) 269(1; *) 270(1; *) 271(1; *)
272(4; *) 273(3; *) 274(1; *) 278(2; *) 279(2; *)
280(1; *) 293(1; *) 321(1; *) 322(1; *) 324(1; *)
327(193; 0.5) 330(2; *) 333(2; *) 334(1; *) 431(1; *)
432(2; *) 464(1; *) 484(3; *) 497(1; *) 512(1; *)
570(1; *)

Syngnathus fuscus, northern pipefish
144(1; *) 145(1; *) 183(1; *) 212(1; *) 214(6; *)
215(1; *) 246(1; *) 256(8; *) 257(2; *) 258(2; *)
260(1; *) 264(1; *) 266(1; *) 270(1; *) 272(3; *)
273(1; *) 274(1; *) 312(1; *) 318(5; *) 320(10; *)

Table 3.--Continued

Syngnathus fuscus--Cont.
321(3; *) 323(2; *) 324(1; *) 325(22; *) 326(1248; 1.8)
327(7120; 10.4) 330(1; *) 331(1; *) 334(40; *) 394(2; *)
396(1; *) 398(1; *) 399(1; *) 400(2; *) 401(1; *)
427(2; *) 430(3; *) 431(3; *) 432(2; *) 434(1; *)
437(2; *) 460(6; *) 461(2; *) 462(2; *) 463(3; *)
464(2; *) 474(8; *) 478(1; *) 479(1; *) 480(8; *)
482(1; *) 483(1; *) 484(15; *) 486(1; *) 487(1; *)
503(3; *) 504(3; *) 505(3; *) 511(1; *) 558(1; *)
565(2; *) 566(3; *) 570(2; *) 598(1; *)

PERCICHTHYIDAE
Morone americana, white perch
300(1; *)

Morone saxatilis, striped bass
16(8; 17.2) 17(1; 2.7) 71(1; 0.9) 72(1; 0.9) 77(1; 1.8) 256(1; 1.4)
320(1; 5.4) 549(1; *) 568(2; 4.1) 580(1; 3.6)

SERRANIDAE
Centropristis striata, black sea bass
21(1; *) 23(1; 0.9) 36(1; *) 43(1; *) 48(1; 0.5)
51(1; 0.5) 82(1; *) 84(6; 1.8) 85(15; 5.9) 111(1; 0.5)
141(1; 0.5) 142(4; 0.9) 143(6; 1.8) 144(1; *) 147(19; 7.3)
171(1; 0.5) 172(1; 0.5) 186(4; *) 196(1; *) 197(1; *)
198(3; 0.5) 200(7; 3.2) 201(11; *) 204(6; 0.5) 205(11; *)
206(9; 1.4) 207(2; *) 212(15; *) 214(1; *) 215(5; 1.8)
232(1; *) 233(26; 0.5) 235(5; 0.5) 236(9; 3.6) 242(1; *)
259(1; *) 260(16; *) 261(4; 0.5) 262(2; *) 263(1; *)
264(3; *) 265(3; 0.5) 266(2; 0.5) 272(2; 0.5) 273(1; 0.5)
274(2; *) 276(2; *) 280(3; *) 281(5; *) 290(1; *)
293(127; 1.4) 294(14; 1.8) 295(46; 4.1) 297(1; *) 336(3; 1.8)
337(1; *) 338(2; *) 339(1; *) 340(2; *) 341(1; *)
342(2; *) 349(2; 1.8) 353(2; 0.9) 354(3; 0.9) 413(6; 0.9)
416(4; *) 422(6; *) 429(1; *) 484(1; *) 519(1; *)
574(1; 0.9) 577(3; 0.9) 578(2; 1.4) 579(2; 0.5) 580(1; *)
584(1; *) 585(1; *) 587(1; 0.5) 588(1; 0.5) 589(1; 0.9)
590(3; 1.8) 592(2; 2.7) 593(7; 5.4) 594(1; *) 606(1; *)
608(1; *) 619(2; 0.5) 620(1; 0.9) 621(1; *) 622(3; 0.9)
623(2; 0.5) 624(2; 0.5) 625(3; 1.4) 626(1; 0.5) 627(1; 1.4)
629(1; *) 638(17; 3.6) 640(8; 1.8) 641(1; *) 642(1; *)
643(7; 2.3) 644(12; 2.7) 647(1; *) 649(1; 0.5) 650(1; 0.5)
651(1; 0.5) 661(1; *) 662(1; *) 665(1; *) 683(1; *)
684(2; *) 685(27; 4.1) 686(2; *) 687(7; 1.8) 688(4; 0.9)
689(19; 2.7) 690(9; 2.3) 691(8; 2.3) 692(1; *) 693(2; *)
694(6; 1.4) 697(2; 0.5) 698(1; *) 699(5; 1.8) 700(3; *)

PRIACANTHIDAE
Priacanthus arenatus, bigeye
293(1; *)

Pristigenys alta, short bigeye
90(1; *)

Table 3.--Continued

APOGONIDAE

Apogon pseudomaculatus, twospot cardinalfish
100(1; *) 221(78; 0.9) 289(1; *)

Apogon sp.
611(1; *) 677(1; *)

BRANCHIOSTEGIDAE

Lopholatilus chamaeleonticeps, tilefish
37(2; 0.5) 40(1; 6.4) 222(1; *) 287(2; 2.7) 347(1; *) 348(1; 1.8)
451(1; *) 536(1; *) 613(1; 3.2) 675(1; *) 678(4; 0.5)

POMATOMIDAE

Pomatomus saltatrix, bluefish
1(1; 2.3) 16(2; *) 17(3; *) 18(2; 5.0) 25(1; 2.7)
29(1; 1.4) 47(1; 3.2) 48(6; *) 53(2; *) 54(1; *)
64(1; *) 65(1; *) 66(2; 0.5) 67(10; 4.1) 68(6; 3.6)
74(1; *) 77(1; 5.0) 78(10; 2.3) 79(2; 0.5) 83(1; 3.2)
90(3; *) 118(1; 1.8) 124(2; *) 130(1; 0.5) 133(1; 0.9)
134(1; 0.5) 136(6; 0.5) 139(1; 0.5) 147(4; 11.3) 149(1; 4.5)
150(101; 2.7) 151(3; *) 182(13; 1.4) 185(2; *) 187(2; *)
189(1; 3.6) 191(1; 0.5) 192(2; *) 193(4; 0.5) 194(24; 1.4)
195(42; 5.9) 210(43; 7.7) 211(3; 0.5) 215(2; 0.9) 232(14; 10.0)
237(8; 0.5) 238(4; 0.5) 239(1; *) 240(1; *) 256(85; 6.4)
257(12; 4.1) 259(11; 13.2) 260(2; 8.2) 262(11; 0.9) 263(1; *)
266(1; 5.0) 267(3; 18.6) 268(1; 2.3) 271(1; 2.7) 272(1; *)
274(1; 3.6) 278(14; 0.9) 279(2; 9.1) 284(1; 5.4) 295(1; 4.5)
298(40; 2.3) 303(1; 4.5) 320(1; 3.6) 322(65; 5.0) 323(4; *)
331(1; 3.6) 340(1; 2.3) 352(5; 29.9) 648(3; *) 687(1; 1.8)

CARANGIDAE

Decapterus macarellus, mackerel scad
207(1; *)

Decapterus punctatus, round scad
89(1; *) 90(5; *) 92(2; *) 138(1; *) 140(72; 0.5)
148(101; 0.9) 149(1; *) 150(5; *) 197(32; 0.5) 198(1; *)
199(1; *) 208(10; *) 209(2; *) 266(1; *) 267(1; *)
268(1; *) 297(17; *)

Naucrates ductor, pilotfish
164(1; *)

Selar crumenophthalmus, bigeye scad
111(5; *) 120(2; *) 148(1; *)

Seriola zonata, banded rudderfish
39(1; *) 138(4; 0.5) 160(1; *)

Trachurus lathami, rough scad
120(1; *) 267(2; *) 280(3; *) 294(1; *)

Vomer setapinnis, Atlantic moonfish
182(2; *) 187(1; *) 193(1; *) 194(1; *) 195(1; *) 210(10; *)
232(1; *) 237(1; *) 298(1; *)

LUTJANIDAE

Lutjanus sp.

212(1; *)	297(1; *)

POMADASYIDAE

Orthopristis chrysoptera, pigfish

242(1; *)	325(2; *)

SPARIDAE

Lagodon rhomboides, pinfish

266(1; *)	277(1; *)	323(1; *)	327(1; *)

Stenotomus chrysops, scup

1(1; *)	3(1; *)	10(1; *)	16(1; *)	19(120; 3.6)
20(5; *)	21(22; 0.5)	22(1; *)	23(57; 1.8)	24(78; 2.7)
28(5; *)	29(7; *)	31(1; *)	45(6; *)	46(11; *)
49(1; *)	50(1; *)	52(68; 2.7)	53(28; 1.4)	58(2; *)
61(3; *)	62(1; *)	63(15; 0.9)	68(1; *)	79(1; *)
81(50; 1.8)	82(3; 0.5)	84(3; *)	85(2; *)	118(2; *)
137(1; *)	139(2; *)	140(19; 0.9)	141(9; 0.9)	143(63; 0.9)
144(37; *)	147(9; 0.5)	148(2; *)	150(2; 0.5)	184(2; *)
186(76; 0.5)	188(1; *)	189(1; *)	193(1; *)	196(4; 0.5)
197(120; 7.3)	198(87; 1.4)	199(170; 14.1)	200(1; *)	202(41; 1.8)
203(1; *)	204(10; 0.9)	205(6; *)	206(201; 8.2)	208(104; 0.5)
209(2; *)	210(7; 0.9)	211(8; 0.5)	212(29; 0.5)	213(1; *)
214(184; 0.9)	215(20; 2.7)	216(21; 1.8)	217(3; 0.5)	226(1; *)
227(6; 0.5)	228(3; 0.5)	231(25; 2.3)	232(2; *)	233(19; 0.9)
234(138; 0.5)	235(1; *)	236(24; 2.3)	242(1; *)	259(454; 31.8)
260(24; 1.4)	261(16; *)	262(1; *)	263(5; *)	264(8; 0.9)
265(137; 5.4)	266(607; 51.3)	267(315; 6.4)	268(763; 16.8)	269(12; 1.4)
271(8; 0.5)	272(1; *)	273(22; 0.5)	274(280; 6.4)	275(1; *)
276(1566; 24.5)	277(350; 9.5)	278(9; *)	279(29; 0.5)	280(180; 10.4)
281(29; 5.4)	282(18; 4.5)	283(23; 6.8)	284(12; 4.1)	291(11; 2.3)
292(4; 0.9)	293(68; 3.6)	294(5; *)	295(288; 5.0)	297(2245; 20.4)
298(3; *)	299(42; *)	321(1; *)	324(1; *)	328(46; 5.0)
329(25; 4.5)	330(82; 26.3)	335(23; 1.8)	336(14; 4.1)	337(102; 25.9)
338(7; 2.3)	339(9; 2.3)	340(35; 24.9)	342(90; 3.6)	343(221; 26.8)
349(117; 68.5)	350(66; 7.7)	351(12; 1.4)	352(1; *)	353(12; 2.3)
354(26; 1.4)	357(4; 0.9)	410(1; *)	413(1; *)	422(1; *)
533(1; *)	540(2; 0.5)	568(1; 0.5)	569(2; 0.5)	571(9; 4.1)
572(1; *)	574(1; *)	575(1; *)	577(23; 4.1)	573(17; 6.4)
579(13; 3.6)	580(3; 0.5)	581(5; 0.5)	583(25; 3.6)	584(18; 2.7)
585(31; 5.0)	586(2; 0.5)	587(3; 0.5)	588(168; 47.2)	590(267; 35.8)
591(5; 0.9)	592(20; 3.2)	593(64; 12.2)	594(53; 8.2)	597(2; 0.9)
598(1; *)	599(3; 0.5)	600(5; 0.9)	601(4; 0.9)	602(1; 0.5)
603(38; 11.3)	607(2; 0.5)	608(1; *)	609(7; 1.8)	618(1; *)
619(1; *)	620(7; 1.4)	621(1; *)	622(4; *)	623(3; *)
624(35; 0.9)	625(5; *)	626(2; *)	627(2; *)	628(1; *)
634(2; *)	635(1; *)	637(41; 0.9)	638(34; 0.9)	639(16; 0.5)
640(9; *)	641(6; *)	642(11; *)	643(12; *)	644(195; 4.1)
645(287; 6.4)	646(23; 0.9)	649(17; 0.5)	650(360; 9.1)	651(4; *)
653(13; 0.5)	654(1; *)	655(47; 1.4)	656(1; *)	659(2; *)
660(1; *)	665(2; *)	668(2; *)	672(1; *)	673(2; *)
674(3; *)	684(17; 0.5)	685(25; 0.5)	687(3; *)	688(3; *)
689(4; *)	690(5; *)	691(2; *)	692(2; *)	693(5; *)
695(1; *)	697(2; *)	699(3; *)	700(24; 0.5)	

SCIAENIDAE

Bairdiella chrysura, silver perch

237(1; *) 242(5; *) 246(1; *) 256(4; 0.5) 318(3; *) 325(3; *)

Cynoscion regalis, weakfish

1(1; 2.3) 63(1; 0.9) 65(3; 3.2) 66(5; 18.6) 67(2; 4.1)
68(6; 6.4) 69(1; *) 70(2; 4.1) 76(1; 2.7) 77(11; 42.2)
78(7; 17.7) 79(3; 14.5) 115(4; 9.5) 116(1; 2.7) 123(1; *)
124(1; *) 126(1; *) 131(1; 1.4) 132(4; 8.6) 134(1; 1.4)
136(5; 5.9) 150(1; *) 182(18; *) 184(5; *) 185(9; 5.9)
187(100; 1.4) 188(1; *) 189(6; *) 190(2; *) 192(29; 0.5)
193(13; 2.3) 194(56; 0.5) 195(295; 3.2) 196(13; *) 209(2; *)
210(61; 3.2) 212(47; 6.8) 213(1; 1.8) 214(1; 1.8) 215(76; 3.2)
232(1; *) 233(1; 2.3) 237(6; *) 238(6; *) 239(1; *)
241(1; *) 242(59; 1.4) 243(1; *) 244(2; *) 245(3; *)
246(1; *) 247(2; *) 256(42; 0.5) 257(11; *) 263(1; 2.3)
266(2; 5.4) 272(29; 3.6) 275(3; 3.6) 276(1; 1.8) 298(27; 0.9)
299(10; *) 301(1; *) 302(2; *) 306(4; *) 309(1; *)
310(3; *) 311(7; *) 316(5; *) 318(72; 0.5) 319(19; 2.3)
320(3; *) 323(18; 0.5) 324(1; *) 325(306; 5.0) 326(145; 4.5)
327(580; 25.4) 332(84; 5.0) 332(512; 16.8) 334(40; 3.2) 340(1; 3.2)
568(2; *)

Leiostomus xanthurus, spot

182(1; *) 192(1; *) 194(5; 0.5) 195(8; 0.9) 210(1; *) 232(1; *)
242(3; *) 256(2; *) 319(1; *)

Menticirrhus saxatilis, northern kingfish

184(1; *) 186(1; *) 187(1; *) 190(3; *) 191(9; 0.5) 196(6; *)
199(1; *) 208(1; *) 210(1; *) 232(1; *) 234(1; *) 254(1; *)
262(2; 0.5) 263(3; 0.5) 271(8; 1.4) 272(19; 4.1) 273(6; 0.9) 275(5; *)
276(1; *) 278(1; *) 298(12; 0.9) 322(6; *) 325(14; *) 326(1; *)
329(1; *) 331(2; *) 332(2; *) 333(1; *) 357(1; *)

Micropogon undulatus, Atlantic croaker

195(1; *) 233(2; 0.9) 242(1; *) 325(2; *)

MULLIDAE

Mullus auratus, red goatfish

90(2; *) 111(1; *) 140(1; *)

CHAETODONTIDAE

Chaetodon ocellatus, spotfin butterflyfish

184(1; *) 322(1; *)

LABRIDAE

Tautoga onitis, tautog

7(1; 1.4) 17(1; 3.2) 70(1; *) 124(1; *) 134(1; 1.4) 240(1; 0.5)
255(12; 4.5) 257(1; *) 258(2; 1.8) 259(9; 19.5) 270(1; 0.5) 272(1; 0.5)
278(1; 0.5) 304(2; 0.9) 307(1; *) 310(1; *) 325(7; 0.5) 327(1; *)
388(2; 0.5) 389(1; *) 437(1; *) 470(2; 1.4) 522(1; 0.5) 554(1; 0.9)
556(2; 0.5) 560(1; 2.3) 561(3; 1.4) 565(3; 3.2) 567(9; 11.8) 568(2; 1.4)
569(1; 1.4) 639(1; 0.9)

Tautogolabrus adspersus, cunner
21(1; *) 50(2; 0.5) 51(1; *) 52(2; *) 53(2; *)
54(16; 2.3) 85(2; *) 120(6; 0.9) 174(1; *) 198(1; 0.5)
206(2; *) 231(1; *) 236(4; *) 241(1; *) 259(92; 14.5)
274(1; *) 304(20; 1.4) 322(1; *) 324(1; *) 334(4; *)
389(592; 34.5) 390(1; *) 437(20; 3.6) 439(43; 3.6) 480(1; *)
501(1; 0.5) 522(18; 1.8) 529(8; 5.0) 544(1; 0.5) 547(16; 1.4)
568(75; 12.7) 569(2; *) 571(2; *) 572(2; *) 575(2; *)
577(31; 5.4) 581(1; *) 594(1; *) 626(2; *) 638(8; 1.4)
640(3; *) 690(1; *) 692(5; 0.9) 697(3; 0.5) 699(11; 0.5)

MUGILIDAE
Mugil curema, white mullet
192(1; *)

SPHYRAENIDAE
Sphyraena borealis, northern sennet
198(1; *) 259(1; *) 261(1; *) 330(3; *)

URANOSCOPIDAE
Astroscopus guttatus, northern stargazer
238(1; *) 242(1; *) 249(1; *) 257(1; *) 258(1; *)

BLENNIIDAE
unidentifiable to genus
522(1; *)

PHOLIDAE
Pholis gunnellus, rock gunnel
105(2; *) 107(1; *) 167(1; *) 196(2; *) 258(4; *) 320(2; *)
336(1; *) 338(1; *) 388(2; *) 566(1; *) 567(4; *) 617(1; *)

AMMODYTIDAE
Ammodytes americanus, American sand lance
28(1; *) 50(1; *) 51(1; *) 53(1; *)
94(2; *) 106(1; *) 110(1019; 21.3) 146(1; *)
156(520; 11.8) 205(1; *) 215(1; *) 231(19874; 536.6)
232(21; 0.5) 236(1; *) 251(15; *) 254(1; *)
273(1; *) 294(2; *) 303(1; *) 325(3; *)
352(2; *) 360(22; *) 362(21; *) 376(29; *)
377(16; *) 378(1; *) 391(1; *) 392(1; *)
393(2; *) 402(4; *) 405(2; *) 426(4; *)
427(5; *) 428(8; *) 429(1; *) 430(2; *)
432(56; 0.9) 433(1; *) 437(1; *) 463(1; *)
474(6; *) 476(2; *) 477(3; *) 509(2; *)
518(2; *) 520(354; 6.4) 521(24; 0.5) 545(56; *)
546(2; *) 547(1; *) 568(22; 0.5) 579(8; *)
591(1; *) 620(1; *) 624(5; *) 625(2; *)
637(53; *) 648(2; *) 650(1; *) 662(304; 10.0)
682(2; *) 687(1; *) 699(2; *)

TRICHIURIDAE
Trichiurus lepturus, Atlantic cutlassfish
420(1; *)

SCOMBRIDAE

Scomber scombrus, Atlantic mackerel

18(1; *) 33(14; 0.9) 36(1; 0.5) 92(16; 0.5) 101(2; *)
164(3; *) 199(1; *) 212(1; *) 282(1; *) 352(1; *)
392(1; 0.5) 410(19; 0.9) 414(46; 2.7) 415(1; *) 422(1; *)
440(102; 34.0) 441(16; 6.4) 447(1; 0.5) 448(1; 0.5) 450(14; 1.8)
451(4; 0.5) 454(2; 0.9) 457(1; *) 515(2; *) 536(2; 0.5)
568(1; 0.5) 569(5; 0.5) 578(1; *) 584(2; *) 586(1; *)
587(16; 2.3) 591(1; 0.5) 597(2; *) 601(1; *) 608(1; 0.5)
615(1; *) 618(5; 1.4) 619(1; *)

STROMATEIDAE

Ariomma bondi, silver-rag

91(1; *) 151(1; *)

Peprilus triacanthus, butterfish

1(2; *) 2(46; 1.8) 3(4; *) 9(10; 0.5)
16(9; 0.5) 17(37; 1.4) 18(2; *) 19(4; 0.5)
21(3; *) 22(1; *) 23(9; 0.5) 24(23; 0.9)
27(34; 1.8) 28(8; 0.5) 29(164; 7.3) 30(138; 10.0)
33(25; 1.4) 34(3; *) 36(5; *) 37(8; 0.9)
38(766; 103.9) 44(2; *) 45(1; *) 46(5; *)
47(5; *) 48(246; 19.5) 49(1; *) 50(353; 20.0)
51(4; *) 52(7; *) 53(38; 3.2) 54(4; 0.5)
61(16; 0.9) 73(1; *) 78(4; *) 79(3; *)
80(238; 3.6) 81(182; 1.8) 82(434; 9.5) 83(37; 0.5)
84(6; 0.5) 87(9; 0.9) 88(106; 1.4) 89(51; 0.9)
90(5120; 3.6) 91(1360; 9.1) 92(17820; 20.4) 96(1; *)
97(11; 1.4) 98(95; 8.6) 101(22; 1.8) 107(35; 1.4)
108(54; 0.9) 109(776; 1.8) 110(184; 2.3) 111(1012; 3.2)
112(1123; 26.8) 113(6; 0.5) 117(1; *) 118(980; 6.4)
119(106; 5.4) 120(1032; 7.3) 123(2; *) 125(1; *)
126(1; *) 128(4; *) 131(2; *) 136(3; 0.5)
137(208; *) 138(388; 0.5) 139(8432; 7.7) 140(1602; 11.3)
143(16; *) 144(344; 0.5) 146(4; *) 147(98; 2.3)
148(29; 0.5) 149(17; 0.5) 150(368; 0.9) 151(3; *)
152(1; *) 154(4; 0.5) 155(25; 2.7) 156(68; 2.7)
157(110; 5.4) 158(2; *) 161(738; 59.9) 163(1; *)
166(1776; 103.4) 167(10; 0.9) 168(4; *) 169(221; 4.1)
170(22; 0.5) 171(78; 1.4) 172(30; 0.5) 173(105; 1.4)
174(2600; 63.5) 175(1233; 47.2) 176(910; 35.4) 177(80; 2.7)
178(279; 1.4) 179(56; 0.5) 180(13; *) 182(14; 0.5)
183(7; *) 185(1; *) 189(1; *) 190(2; *)
191(3; *) 192(3; *) 193(3; *) 194(8; 0.5)
195(27; 0.9) 197(590; 4.5) 198(1200; 5.4) 199(240; 0.9)
202(1; *) 203(4; *) 204(5; *) 205(1; *)
206(3; *) 207(1; *) 208(14220; 35.8) 209(552; 1.4)
210(27; 0.5) 211(1463; 8.6) 212(59; *) 214(26 *)
215(462; 5.9) 216(92; 0.9) 217(186; 13.6) 220(37; 1.8)
222(87; 3.6) 224(2; *) 225(1; *) 226(2; *)
228(34; 1.4) 229(2; *) 230(5; *) 232(297; 4.1)
233(1; *) 235(5; *) 237(20; 1.8) 238(11; 0.5)
239(29; 1.4) 240(2; *) 244(4; 0.5) 249(2; *)
256(62; 3.2) 257(12; 0.5) 258(7; 0.5) 259(203; 29.5)
260(3; *) 262(9; *) 263(67; 0.9) 264(2; *)

Table 3.--Continued

Peprilus triacanthus--Cont.

265(3; *)   266(427; 6.4)   267(558; 9.5)   268(2455; 33.6)
269(3368; 18.1)   270(13; *)   271(270; 5.4)   272(14; *)
273(14; *)   274(102; 0.5)   275(3; *)   276(123; 0.9)
278(184; 0.9)   279(340; 1.8)   280(1; *)   281(1; *)
284(14; 1.4)   288(66; 5.9)   289(6; 0.5)   290(1210; 73.0)
292(13; 1.4)   294(2; *)   297(203; 5.0)   298(504; 5.4)
302(2; *)   311(1; *)   318(1; *)   319(1; *)
321(8; *)   322(72; 4.1)   323(8; 0.9)   324(1; *)
329(53; 2.7)   330(8; 0.9)   335(1; *)   337(16; 1.8)
338(4; *)   349(3; *)   352(55; 0.5)   353(3; 0.5)
356(1; *)   410(5; 0.5)   413(36; 0.9)   414(2; *)
416(15; *)   422(4; *)   424(2; 0.5)   441(1; *)
442(102; 3.2)   444(1; *)   446(1; 0.5)   448(1; *)
449(40; 2.3)   450(3; 0.5)   451(2; *)   452(5; 0.9)
453(4; 0.9)   455(2; 0.5)   456(1; *)   458(1; *)
522(1; *)   532(38; 1.4)   533(17; 0.9)   534(23; 1.8)
536(58; 3.6)   540(5; 0.9)   542(7; 1.4)   556(2; *)
567(1; *)   568(24; 2.7)   570(12; 1.4)   573(2; *)
577(4; 0.5)   578(1; *)   579(1; *)   580(19; 1.4)
583(1; *)   584(4; 0.5)   585(5; 0.5)   587(8; 0.9)
588(6; 0.5)   589(9; 1.4)   590(9; 1.4)   591(1; *)
592(8; 1.4)   594(2; *)   603(13; 0.9)   604(7; 0.9)
605(43; 5.4)   608(3; 0.5)   609(1; *)   610(39; 1.8)
611(3; *)   613(19; 1.8)   615(1; *)   617(2; 0.5)
620(1; *)   623(1; *)   626(1; *)   628(8; 0.5)
630(10; 0.5)   631(3; *)   633(3; *)   636(2; *)
638(358; 38.6)   639(39; 3.2)   645(6; *)   650(84; 6.4)
651(5; 0.5)   654(1; *)   655(42; 2.7)   659(1; *)
660(1; *)   670(120; 6.4)   671(267; 29.5)   672(16; 1.8)
675(64; 3.2)   677(1; *)   678(22; 1.4)   679(2; 0.5)
685(22; 0.9)   686(1; *)   691(1; *)   692(3; *)
693(1; *)   694(4; *)   695(2; *)   700(36; 4.1)

SCORPAENIDAE

Helicolenus dactylopterus, blackbelly rosefish

33(16; *)   34(1; *)   36(93; 0.5)   38(17; *)   39(65; 2.7)   40(6; *)
99(36; 1.4)   100(29; 0.9)   101(25; *)   102(15; *)   162(61; *)   163(26; 0.5)
218(2; *)   219(4; *)   221(78; 0.9)   286(93; 4.1)   289(7; 0.5)   290(2; *)
344(6; *)   347(7; *)   420(9; 0.5)   440(1; *)   449(1; *)   450(19; *)
451(6; *)   458(31; 2.7)   531(47; *)   533(1; *)   538(32; 0.5)   539(13; *)
604(2; *)   605(4; *)   610(2; *)   611(17; 0.5)   612(58; 2.3)   613(1; *)
669(58; 3.2)   670(4; *)   675(9; *)   676(5; *)   677(20; *)

Scorpaena plumieri, spotted scorpionfish

38(1; *)

Sebastes marinus, ocean perch

605(2; *)   610(1; *)   670(2; *)   692(1; *)

TRIGLIDAE

Peristedion miniatum, armored searobin

102(2; *)   162(8; 0.9)   164(1; *)   218(9; 0.5)   219(3; *)
222(18; 4.1)   223(4; 0.9)   287(4; *)   289(1; *)   344(67; 8.6)
347(5; 0.9)   412(4; 0.5)   418(43; 7.7)   419(6; 1.8)   440(5; 0.9)

Peristedion miniatum--Cont.

442(1; *) 449(1; *) 450(1; *) 451(10; 2.3) 538(91; 12.2)
539(2; 0.5) 604(1; 0.5) 605(29; 3.6) 606(8; 0.9) 607(1; *)
611(1; *) 673(1; *) 675(5; 0.9) 676(4; 0.9) 677(8; 1.8)

Prionotus carolinus, northern searobin

19(1; *) 42(1; *) 43(1; *) 46(40; 6.8) 56(1; *)
57(1; *) 63(1; *) 68(1; *) 81(1; *) 82(3; 0.5)
84(9; 0.9) 85(3; 0.5) 86(4; 0.9) 92(1; *) 109(7; 1.4)
111(104; 17.7) 112(1; *) 117(22; 3.2) 118(1; *) 120(3; 0.5)
122(1; *) 137(30; 2.7) 138(12; 0.9) 139(1; *) 140(3; 0.5)
142(3; 0.5) 143(14; 1.8) 145(2; 0.5) 149(1; *) 168(3; 0.5)
169(10; 1.8) 170(2; 0.5) 172(3; 0.5) 197(1; *) 198(5; 0.5)
199(7; *) 200(13; *) 202(2; 0.5) 204(1; *) 205(24; 2.7)
206(15; 0.5) 207(4; *) 208(1; *) 209(16; *) 210(3; 0.5)
211(5; 0.5) 212(79; 3.2) 214(14; 1.8) 215(79; 3.6) 216(1; *)
217(1; 0.5) 232(3; 0.5) 233(65; 7.3) 234(9; 1.4) 235(25; 3.2)
236(4; 0.5) 259(3; 0.5) 260(18; *) 261(2; 0.5) 262(3; 0.5)
263(39; *) 264(15; *) 265(15; 0.5) 266(5; *) 268(1; *)
270(1; *) 271(1; *) 272(3; *) 273(4; *) 274(20; 0.5)
275(3; *) 276(12; 1.4) 277(11; 1.4) 278(2; *) 279(2; *)
281(1; 0.5) 283(1; *) 291(3; 0.9) 293(105; 5.4) 294(6; *)
295(24; 0.9) 296(1; *) 297(2; *) 298(1; *) 321(17; *)
323(1; *) 324(10; *) 328(2; 0.5) 329(5; *) 330(2; *)
331(1; *) 335(5; 0.9) 337(5; 0.9) 339(1; *) 340(1; *)
341(1; *) 342(3; *) 343(1; *) 349(2; 0.5) 350(9; 1.8)
353(5; *) 354(2; *) 356(2; *) 357(1; *) 398(1; *)
409(1; *) 410(86; 19.5) 413(1; *) 414(7; 1.8) 416(4; *)
421(3; *) 430(1; *) 432(2; *) 440(1; *) 442(1; *)
448(4; 1.4) 470(1; *) 489(1; *) 534(1; *) 535(4; 0.9)
540(14; 2.7) 541(1; *) 543(2; *) 567(1; *) 568(2; 0.5)
570(4; 0.5) 572(1; *) 581(1; *) 582(2; *) 585(1; *)
586(1; *) 589(5; 0.9) 590(3; 0.5) 592(1; *) 593(8; 2.3)
594(1; *) 597(1; *) 598(1; *) 599(1; *) 600(2; *)
601(2; *) 602(1; *) 614(1; *) 617(1; *) 619(1; *)
621(1; *) 622(1; *) 623(2; *) 624(8; 0.9) 625(5; *)
626(1; *) 637(2; *) 639(9; 0.5) 640(2; *) 641(1; *)
642(1; *) 643(6; 0.5) 644(10; 1.4) 645(4; *) 649(3; 0.5)
650(1; *) 653(1; *) 654(1; *) 655(4; *) 658(1; *)
661(1; *) 667(1; *) 683(20; 2.7) 684(6; 0.9) 685(3; *)
686(26; 2.3) 687(11; 0.9) 688(134; 16.8) 689(16; 1.4) 690(41; 5.4)
691(3; *) 697(1; *) 700(3; 0.5)

Prionotus evolans, striped searobin

17(1; *) 19(12; 5.0) 20(1; 0.5) 21(2; 1.4) 23(1; *)
29(1; *) 61(2; 0.9) 63(44; 3.6) 69(1; *) 81(1; 0.5)
85(3; 0.9) 86(1; 0.9) 90(8; 3.6) 92(3; 0.9) 109(3; 1.4)
111(38; 14.1) 112(3; 1.4) 113(1; *) 115(2; 0.5) 137(18; 7.3)
138(13; 5.4) 139(2; 0.5) 143(1; *) 144(8; 2.7) 145(2; *)
150(1; 0.5) 179(2; 0.5) 185(4; 1.4) 192(1; *) 195(1; *)
197(3; 0.9) 198(10; 0.5) 199(2; *) 200(14; 0.5) 201(1; *)
202(17; 0.9) 203(1; *) 205(3; *) 206(1; *) 207(1; *)
209(5; 0.5) 210(6; 2.3) 212(71; 10.4) 213(1; 0.5) 214(5; 0.5)
215(55; 23.6) 216(2; 0.9) 217(1; 0.9) 233(7; 0.5) 234(10; *)
237(1; *) 242(2; *) 243(1; *) 256(6; *) 258(1; *)

Table 3.--Continued

Prionotus evolans--Cont.
259(2; 0.5) 260(8; *) 261(2; *) 262(10; 4.5) 263(7; 2.7)
264(1; *) 265(3; 0.9) 266(3; 1.4) 269(17; 6.8) 270(1; *)
271(2; *) 272(9; 0.5) 273(5; 1.8) 274(13; 6.4) 276(7; 1.8)
278(1; *) 281(1; 0.5) 293(2; *) 294(1; 0.5) 295(8; 0.9)
298(4; *) 311(1; *) 318(1; *) 321(1; *) 323(6; *)
324(2; *) 325(1; *) 327(1; *) 328(2; 0.9) 332(2; *)
333(1; *) 336(1; 0.5) 337(3; 1.4) 338(13; 7.3) 339(7; 3.2)
340(4; 1.4) 341(1; *) 342(3; 0.9) 343(2; 1.4) 350(12; 6.8)
354(1; *) 356(1; *) 357(1; 0.5) 390(1; *) 540(1; *)
565(1; 0.5) 568(3; 1.8) 569(2; 0.9) 570(2; 0.9) 580(1; 0.5)
624(1; 0.5) 637(1; *) 638(1; *) 639(12; 4.5) 640(1; 0.5)
644(2; 0.5) 645(4; 2.3) 649(1; 0.5) 685(1; 0.5) 688(1; 0.5)
689(1; 0.9) 690(4; 0.9) 700(3; 1.4)

COTTIDAE

Hemitripterus americanus, sea raven
31(1; *) 42(1; *) 57(23; 18.1) 58(1; 0.5) 93(1; *)
105(1; *) 152(1; 0.5) 153(1; *) 157(1; 0.5) 167(1; *)
332(1; *) 336(3; 1.8) 397(1; *) 405(1; 0.9) 407(1; 0.5)
430(1; 1.4) 437(4; 2.3) 461(1; 0.9) 476(1; 0.5) 507(2; 2.3)
513(1; 0.5) 522(4; 2.3) 576(2; 1.8) 595(1; 0.5) 627(1; 0.5)
654(1; *) 692(1; 0.9) 695(1; *)

Myoxocephalus aenaeus, grubby
16(1; *) 68(1; *) 77(1; *) 195(2; *) 196(1; *) 302(2; *)
308(1; *) 312(1; *) 359(1; *) 361(2; *) 386(3; *) 387(5; *)
391(1; *) 484(1; *) 567(26; *)

Myoxocephalus octodecemspinosus, longhorn sculpin
55(1; *) 56(2; 0.5) 57(8; 2.3) 58(1; *) 87(1; *) 94(1; *)
105(7; *) 106(1; *) 107(4; *) 152(12; 0.5) 153(14; 0.9) 155(5; 0.9)
157(1; 0.5) 167(2; *) 168(1; *) 225(2; *) 226(2; *) 258(1; *)
280(2; *) 296(1; *) 320(32; 0.5) 333(1; *) 336(2; 1.8) 354(1; *)
376(1; 0.5) 388(4; *) 389(16; 3.6) 390(1; *) 391(4; 0.9) 392(3; 0.9)
393(1; *) 397(2; *) 398(1; *) 400(1; *) 405(2; 0.5) 429(1; 0.5)
430(1; *) 431(2; 0.5) 432(1; 0.5) 435(2; 0.5) 436(2; 0.5) 437(3; 0.5)
438(4; 0.9) 439(3; 0.5) 445(1; 0.5) 460(1; *) 462(1; *) 463(1; *)
464(1; *) 467(1; *) 476(1; *) 479(2; 0.5) 480(1; *) 483(1; *)
485(2; 0.5) 489(2; 0.5) 501(1; *) 502(4; 1.4) 503(6; 1.4) 504(2; *)
505(1; *) 510(2; 0.5) 511(1; 0.5) 512(5; 1.4) 513(3; 0.5) 522(1; *)
524(1; 0.5) 544(14; 1.8) 545(1; 0.5) 568(1; *) 575(2; 0.9) 577(1; *)
582(1; *) 584(1; *) 585(3; *) 586(8; 1.4) 587(5; 1.4) 588(1; 0.5)
591(4; 1.4) 594(1; *) 595(3; 0.9) 596(3; 0.9) 597(2; 0.5) 598(2; 0.5)
600(1; *) 608(1; 0.5) 617(2; 0.9) 619(2; 0.5) 620(2; 0.5) 621(1; *)
642(1; *) 654(1; *) 666(2; *)

Myoxocephalus scorpius, shorthorn sculpin
184(1; *)

CYCLOPTERIDAE

Liparis sp., seasnail
218(1; *) 225(1; *) 226(1; *) 334(1; *) 401(4; *) 426(1; *)
430(1; *) 439(6; *) 475(1; *)

Table 3.--Continued

BOTHIDAE

Citharichthys arctifrons, Gulf Stream flounder

36(1; *)   37(2; *)   56(1; *)   94(9; *)   102(3; *)
104(47; *)   152(84; 0.5)   153(112; 0.9)   158(8; *)   160(56; 0.5)
161(108; 0.5)   162(51; *)   163(30; 0.5)   165(3; *)   167(51; 0.5)
168(1; *)   183(1; *)   217(104; 0.5)   218(46; *)   219(53; *)
221(13; *)   224(26; *)   225(8; *)   226(3; *)   280(4; *)
281(32; *)   285(16; *)   287(2; *)   289(24; *)   290(41; *)
340(8; *)   342(3; *)   343(3; *)   344(20; *)   346(4; *)
347(44; *)   348(196; *)   357(1; *)   410(20; *)   415(7; *)
416(14; *)   417(1; *)   421(73; *)   424(27; 0.5)   440(2; *)
444(104; *)   445(2; *)   449(2; *)   450(12; *)   451(4; *)
455(3; *)   457(1; *)   458(4; *)   531(1; *)   533(2; *)
535(1; *)   538(5; *)   539(6; *)   544(4; *)   545(1; *)
573(1; *)   602(2; *)   604(2; *)   605(1; *)   607(10; *)
608(4; *)   609(3; *)   610(1; *)   611(10; *)   612(1; *)
613(5; *)   615(3; *)   616(1; *)   619(6; *)   667(6; *)

Etropus microstomus, smallmouth flounder

21(2; *)   33(22; *)   34(9; *)   40(1; *)   41(1; *)
44(1; *)   59(2; *)   84(32; *)   85(2; *)   86(1; *)
90(19; *)   92(2; *)   93(14; *)   96(2; *)   97(4; *)
99(16; 0.9)   100(22; *)   105(15; *)   106(3; *)   115(1; *)
117(8; *)   138(2; *)   139(4; *)   140(1; *)   142(1; *)
143(10; *)   144(14; *)   145(2; *)   155(1; *)   156(3; *)
157(4; *)   166(1; *)   179(1; *)   197(1; *)   198(1; *)
200(8; *)   201(1; *)   202(7; *)   203(1; *)   206(1; *)
207(2; *)   208(7; *)   209(8; *)   210(2; *)   212(44; *)
214(3; *)   215(141; 1.4)   223(14; *)   227(1; *)   228(3; *)
229(1; *)   233(6; *)   234(17; *)   235(3; *)   237(1; *)
238(1; *)   242(1; *)   243(1; *)   256(25; *)   257(20; *)
258(3; *)   259(3; *)   260(32; *)   261(38; *)   263(115; *)
264(22; *)   265(24; *)   266(1; *)   270(2; *)   271(6; *)
272(96; *)   273(36; *)   274(6; *)   275(34; *)   277(4; *)
278(3; *)   293(42; *)   294(34; *)   295(1; *)   296(24; *)
309(2; *)   316(4; *)   318(54; *)   319(11; *)   320(8; *)
321(66; *)   322(81; *)   323(13; *)   324(2; *)   325(30; *)
326(19; 0.5)   327(261; 0.5)   329(2; *)   331(14; *)   332(46; *)
333(28; *)   334(1; *)   335(1; *)   337(7; *)   338(19; *)
361(1; *)   392(20; *)   393(11; *)   394(4; *)   395(4; *)
396(1; *)   397(12; *)   398(1; *)   405(1; *)   407(4; *)
409(1; *)   422(4; *)   426(7; *)   427(14; *)   428(10; *)
429(2; *)   430(14; *)   431(31; *)   432(7; *)   433(2; *)
434(3; *)   435(2; *)   437(1; *)   438(7; *)   461(7; *)
462(7; *)   463(10; *)   464(2; *)   466(2; *)   467(1; *)
470(2; *)   475(8; *)   476(1; *)   477(3; *)   479(3; *)
480(1; *)   482(1; *)   484(3; *)   502(5; *)   503(1; *)
504(9; *)   505(21; *)   506(1; *)   507(3; *)   509(1; *)
513(3; *)   516(1; *)   521(11; *)   525(1; *)   572(4; *)
574(2; *)   576(15; 0.5)   577(2; *)   582(2; *)   583(17; 0.5)
584(9; *)   585(3; *)   596(5; *)   597(6; *)   599(1; *)
600(6; *)   603(1; *)   614(1; *)   615(1; *)   621(1; *)

Etropus microstomus--Cont.

622(7; *)	623(19; *)	624(4; *)	639(2; *)	640(10; *)
641(2; *)	642(9; *)	643(25; *)	644(7; *)	645(6; *)
646(3; *)	651(1; *)	652(2; *)	655(1; *)	656(5; *)
657(1; *)	658(6; *)	659(1; *)	661(1; *)	666(6; *)
668(3; *)	669(1; *)	671(13; *)	672(30; *)	673(33; *)
674(50; *)	675(4; *)	676(2; *)	677(5; *)	678(9; *)
679(4; *)	680(4; *)	681(20; *)	685(1; *)	686(1; *)
687(17; *)	688(10; *)	689(4; *)	690(9; *)	691(1; *)
692(2; *)	693(2; *)	694(3; *)	695(3; *)	

Monolene sessilicauda, deepwater flounder

102(1; *)

Hippoglossina oblonga, fourspot flounder (See: Gutherz 1967)

19(8; 0.9)	29(11; 1.8)	21(28; 4.1)	22(18; 2.3)	28(1; *)
31(5; 0.9)	32(6; 0.9)	34(3; 0.5)	37(2; *)	42(9; 0.9)
43(31; 3.6)	44(8; 0.9)	45(3; 0.5)	46(13; 2.3)	53(1; 0.5)
54(1; 0.5)	55(9; 0.9)	56(4; 0.5)	57(6; 0.5)	58(16; 0.9)
59(8; 1.4)	60(3; 0.5)	80(1; *)	82(8; 0.5)	83(2; *)
84(3; *)	85(2; 0.5)	86(53; 5.9)	87(40; 5.4)	88(2; *)
89(7; 0.9)	91(7; 0.9)	93(41; 5.0)	94(7; 1.4)	96(19; 2.3)
97(10; 0.9)	98(10; 1.4)	100(1; *)	101(2; 0.5)	104(26; 3.2)
105(35; 5.4)	106(42; 5.0)	107(11; 1.4)	112(38; 3.6)	113(7; 0.5)
114(7; 0.5)	115(54; 7.3)	116(35; 4.5)	117(46; 5.0)	119(3; *)
141(4; *)	142(40; *)	143(3; *)	144(5; *)	145(21; *)
146(16; 1.4)	147(1; *)	149(2; *)	152(65; 10.9)	153(71; 9.5)
154(1; *)	155(13; 1.4)	156(9; 1.4)	157(3; 0.5)	158(23; 3.2)
159(8; 0.9)	160(44; 6.8)	161(11; 1.4)	162(1; 0.5)	166(14; 1.8)
167(22; 2.7)	175(4; *)	176(6; 0.5)	177(20; 1.8)	178(2; *)
179(1; *)	180(1; *)	181(1; *)	200(4; *)	201(5; *)
202(16; *)	204(15; *)	205(11; *)	206(4; *)	208(1; *)
209(7; *)	212(25; *)	213(26; 0.5)	214(28; 0.5)	215(74; 0.5)
217(9; 0.9)	218(4; 0.9)	223(97; 11.3)	224(59; 7.7)	225(50; 6.8)
226(115; 18.1)	227(47; 6.4)	228(12; 1.4)	229(6; 0.9)	230(18; 2.3)
231(2; *)	233(10; *)	234(3; *)	235(7; *)	236(2; *)
260(15; *)	261(8; *)	262(45; 0.5)	263(40; *)	264(34; *)
265(30; *)	266(4; *)	270(4; *)	271(7; *)	272(74; 0.9)
273(29; 0.5)	274(46; 0.5)	275(66; 0.9)	276(15; 2.7)	277(22; 0.9)
278(1; *)	280(61; 9.1)	281(30; 5.9)	282(19; 3.6)	283(8; 0.9)
285(13; 1.4)	287(3; 0.5)	288(2; 0.5)	290(5; 0.5)	291(54; 9.1)
292(9; 1.8)	293(24; 0.5)	294(20; 0.5)	295(7; *)	296(5; 0.5)
297(3; *)	321(5; *)	322(4; *)	323(38; 0.5)	324(34; *)
328(11; 1.8)	329(4; *)	330(42; 1.4)	335(14; 2.3)	336(7; 1.4)
337(60; 8.2)	338(79; 11.8)	339(6; 0.9)	340(100; 10.9)	341(20; 0.5)
342(62; 7.7)	343(41; 5.4)	344(1; *)	347(1; *)	348(2; *)
349(30; 3.6)	350(10; 1.8)	353(8; *)	354(6; *)	356(17; *)
357(17; 0.9)	397(4; *)	398(18; 0.5)	406(7; *)	407(3; 0.5)
409(9; 1.4)	410(20; 4.5)	411(12; 2.7)	412(10; 1.4)	413(1; *)
414(7; 0.9)	415(20; 4.1)	416(22; 4.1)	421(37; 5.0)	422(53; 7.3)
423(7; 0.5)	424(2; 0.5)	430(1; *)	431(1; *)	432(6; *)
434(1; *)	437(1; *)	439(1; *)	440(35; 7.3)	441(7; 2.3)
442(15; 2.3)	443(2; *)	444(14; 1.8)	445(2; *)	446(1; *)
447(12; 1.8)	448(17; 2.7)	449(4; 1.4)	450(1; *)	452(9; 1.4)

Hippoglossina oblonga--Cont.

453(6; 0.9)	455(7; 0.9)	456(7; 1.4)	457(6; 0.9)	477(1; *)
479(1; *)	503(1; 0.5)	513(5; 0.5)	516(1; *)	522(4; 0.5)
526(1; *)	528(5; 0.9)	529(2; *)	530(2; 0.5)	532(2; *)
533(3; 0.5)	534(5; 0.9)	535(61; 8.2)	538(7; 1.8)	539(10; 2.3)
540(13; 1.8)	541(3; 0.5)	542(2; 0.5)	543(9; 1.8)	544(5; 1.4)
545(13; 1.8)	569(2; 0.9)	570(2; 0.5)	571(6; 1.4)	573(1; *)
575(10; 1.8)	576(13; 0.9)	578(1; *)	579(4; 0.5)	580(1; *)
581(1; *)	582(3; *)	583(6; 0.5)	584(11; 3.2)	585(13; 1.8)
586(35; 4.1)	587(9; 1.8)	588(1; *)	589(4; 0.9)	590(3; 0.9)
592(6; 0.9)	593(3; 0.9)	594(14; 2.7)	595(17; 3.6)	596(26; 3.2)
597(20; 2.3)	598(16; 2.3)	599(7; 0.9)	600(30; 5.0)	601(98; 13.2)
602(68; 7.3)	603(29; 3.6)	604(10; 1.8)	605(6; 2.3)	606(12; 1.8)
607(3; 0.9)	608(6; 1.8)	609(8; 1.4)	610(9; 1.8)	613(2; *)
614(11; 1.4)	615(21; 2.7)	616(14; 1.8)	617(4; 0.9)	618(4; 0.5)
619(21; 3.6)	620(9; 1.8)	621(7; 0.9)	622(5; 0.9)	627(3; 0.5)
638(6; 0.9)	640(13; 2.3)	641(27; 5.4)	642(31; 5.0)	643(54; 9.5)
644(7; 1.4)	645(4; 0.9)	647(2; *)	650(10; 2.3)	652(10; 1.8)
653(10; 0.9)	654(72; 10.0)	655(7; 1.4)	656(4; 0.5)	657(8; 1.4)
658(40; 5.4)	659(4; 0.5)	660(3; 0.5)	661(11; 1.8)	662(3; *)
663(7; 0.9)	664(3; *)	665(16; 2.3)	666(33; 5.0)	667(10; 1.4)
668(19; 2.7)	670(4; 0.5)	671(18; 2.3)	672(11; 1.8)	673(28; 3.6)
674(18; 1.8)	675(26; 6.8)	676(1; *)	677(2; *)	678(27; 4.1)
679(25; 3.6)	680(9; 1.4)	681(13; 1.4)	682(7; 0.9)	683(4; 0.5)
685(6; 0.9)	686(7; 0.9)	687(19; 2.3)	688(27; 4.5)	689(2; *)
690(26; 5.0)	691(41; 5.4)	692(22; 5.0)	693(38; 9.1)	694(11; 1.8)
695(7; 1.8)	696(1; *)	697(8; 1.4)	698(4; 0.5)	700(7; 0.9)

Paralichthys dentatus, summer flounder

9(2; 0.9)	16(4; 3.2)	17(9; 10.0)	18(3; 3.2)	19(8; 6.4)
20(4; 3.6)	21(21; 14.5)	23(3; 2.7)	28(6; 9.5)	29(2; *)
42(2; 0.9)	43(1; 0.5)	45(3; 1.4)	46(8; 8.6)	47(2; 1.4)
48(5; 7.3)	50(8; 5.4)	52(12; 6.8)	53(5; 2.3)	55(2; 1.4)
56(3; 1.8)	57(1; 0.5)	59(1; 0.5)	61(8; 10.9)	62(1; 0.5)
63(12; 2.7)	64(2; 1.4)	67(5; 3.2)	69(5; 4.1)	70(12; 8.2)
71(1; *)	72(1; *)	76(1; 0.9)	77(4; 5.0)	78(16; 21.8)
79(8; 5.9)	80(1; 1.4)	81(10; 10.9)	84(2; 2.7)	85(1; 1.4)
90(40; 38.6)	92(27; 36.3)	111(1; 0.5)	115(2; 0.9)	120(1; 1.8)
122(3; 2.3)	123(7; 5.0)	134(1; 0.5)	135(1; 0.5)	137(50; 41.3)
138(16; 10.9)	139(3; 2.7)	140(16; 16.8)	142(1; 0.9)	143(3; 2.7)
144(8; 10.0)	150(3; 3.2)	184(1; 0.9)	185(1; 0.5)	186(2; 0.9)
187(4; 2.7)	189(2; 1.8)	192(3; 1.8)	193(6; 5.4)	194(2; 1.4)
195(7; 5.4)	196(21; 14.5)	197(35; 27.2)	198(13; 10.9)	199(17; 15.4)
200(2; 1.4)	202(16; 1.4)	203(1; 0.9)	204(4; 4.1)	205(3; 2.7)
206(11; 14.1)	207(15; 14.5)	208(3; 3.2)	209(40; 38.1)	210(9; 10.0)
211(4; 2.3)	212(11; 12.7)	213(5; 8.6)	214(9; 16.8)	215(18; 17.7)
217(1; 0.5)	232(17; 7.7)	233(70; 54.9)	234(22; 16.8)	235(10; 16.8)
236(5; 9.1)	237(1; *)	238(3; *)	242(3; *)	243(1; *)
256(20; 1.8)	257(4; 0.5)	258(1; *)	259(5; 2.7)	260(3; 1.8)
261(9; 3.6)	262(22; 7.7)	263(8; 3.6)	264(2; 1.4)	266(2; 2.3)
267(16; 21.3)	268(4; 7.3)	269(2; 1.4)	270(5; 3.2)	271(8; 6.4)
272(4; 0.9)	273(2; 0.5)	274(5; 2.7)	275(2; *)	276(4; 4.1)
277(15; 18.6)	278(3; 1.8)	279(2; 1.8)	280(2; 1.8)	281(2; 2.7)
282(1; 2.3)	288(1; 2.3)	290(1; 4.1)	291(2; 3.2)	293(13; 5.9)
294(2; 1.8)	295(10; 10.0)	297(3; 2.7)	298(14; *)	300(1; *)

Paralichthys dentatus--Cont.
312(1; *) 318(2; *) 320(6; *) 321(21; 1.8) 322(2; *)
323(10; 0.5) 324(4; 2.3) 325(3; *) 326(20; 0.9) 327(1; *)
328(14; 15.4) 329(1; *) 330(4; 3.2) 331(2; 2.7) 332(13; 5.0)
333(7; 6.4) 334(21; 10.4) 335(7; 4.5) 337(2; 8.6) 338(2; 2.3)
340(3; 4.1) 341(5; 3.6) 343(3; 2.7) 349(5; 5.9) 351(1; *)
352(1; 0.9) 353(2; 0.9) 354(8; 1.8) 356(1; *) 357(1; 0.5)
387(1; *) 389(1; *) 390(1; *) 393(1; *) 394(1; *)
395(1; *) 398(1; *) 404(1; *) 405(2; *) 406(1; *)
410(3; 1.8) 413(21; 21.8) 415(1; *) 416(2; 1.8) 428(1; *)
436(1; *) 437(1; *) 438(4; *) 442(3; 5.9) 447(1; 1.4)
448(18; 14.5) 449(1; 0.9) 451(1; 1.8) 454(1; *) 486(1; *)
487(2; *) 503(1; *) 521(1; *) 522(1; *) 532(4; 9.5)
533(9; 11.8) 535(7; 4.1) 539(2; 4.1) 540(2; 0.9) 542(1; *)
543(2; 0.5) 545(2; 1.4) 546(1; *) 556(1; 0.5) 567(1; 0.5)
568(1; *) 569(6; 3.2) 570(37; 11.8) 571(1; 0.5) 572(2; 0.9)
573(2; 1.4) 577(4; 2.3) 579(6; 2.7) 580(3; 1.4) 581(1; *)
582(1; 0.5) 583(1; 0.9) 584(1; 2.7) 585(4; 3.2) 586(1; 0.5)
589(3; 1.8) 592(4; 4.5) 593(6; 5.0) 594(3; 2.3) 595(1; 0.5)
599(1; 0.5) 600(1; 0.5) 601(3; 3.2) 615(2; 1.8) 616(1; 0.5)
619(1; 1.4) 620(1; *) 622(1; *) 623(11; 4.1) 624(26; 8.6)
625(24; 8.2) 626(7; 1.4) 627(1; 0.9) 628(2; 0.9) 629(2; 0.9)
634(2; 0.9) 635(2; *) 637(59; 25.9) 638(6; 3.2) 639(34; 15.4)
640(4; 2.3) 641(7; 3.6) 642(2; 0.9) 643(12; 6.8) 644(96; 54.0)
645(38; 20.0) 646(60; 38.1) 648(3; 1.8) 649(23; 16.3) 650(9; 5.9)
651(2; 2.7) 653(12; 12.7) 655(38; 28.1) 660(1; 0.9) 663(1; 0.9)
670(1; 3.6) 683(3; *) 684(15; 7.3) 685(9; 6.8) 687(11; 5.4)
688(11; 4.5) 689(10; 5.0) 690(48; 28.1) 691(24; 12.2) 692(4; 3.2)
693(3; 1.4) 694(4; 1.8) 696(3; 1.4) 697(4; 2.7) 698(4; 2.3)
699(1; 1.4) 700(52; 29.5)

Scophthalmus aquosus, windowpane
9(1; 0.5) 14(14; 2.7) 16(3; 0.5) 17(10; 1.8) 19(52; 10.9)
20(19; 5.4) 21(51; 14.1) 22(1; 0.5) 23(2; *) 24(1; *)
25(1; *) 27(2; 0.5) 28(22; 5.4) 29(10; 2.7) 30(1; *)
42(14; 3.6) 43(6; 1.4) 44(57; 11.8) 45(71; 16.8) 46(263; 58.5)
47(10; 2.3) 48(9; 1.8) 49(3; 0.5) 50(2; 0.5) 51(1; *)
52(5; 1.4) 53(2; 0.5) 55(5; 0.9) 57(2; 0.5) 58(1; 0.5)
59(6; 1.4) 60(2; 0.5) 62(1; *) 70(2; *) 71(1; *)
72(1; *) 80(31; 7.3) 81(14; 4.1) 82(16; 3.2) 83(10; 2.7)
84(62; 10.4) 85(52; 10.9) 86(46; 10.9) 87(22; 5.4) 90(13; 3.2)
91(2; 0.5) 92(23; 4.5) 93(13; 4.1) 94(1; 0.5) 105(7; 1.8)
106(9; 1.4) 107(6; 1.4) 108(2; *) 109(3; 0.5) 110(1; *)
111(8; 2.3) 112(23; 4.5) 113(2; 0.5) 114(5; 1.4) 115(106; 23.6)
116(199; 42.2) 117(135; 26.3) 118(7; 1.4) 119(10; 2.3) 120(17; 3.2)
122(1; *) 123(1; *) 137(20; 4.5) 138(9; 0.9) 139(12; 0.5)
140(7; 1.4) 141(41; 9.5) 142(29; 5.9) 143(22; 3.2) 144(10; 1.8)
145(18; 4.1) 146(2; 0.5) 147(1; *) 149(1; *) 150(13; 2.3)
151(1; *) 152(6; 1.4) 153(21; 4.5) 155(5; 0.9) 156(12; 2.3)
167(18; 4.1) 168(8; 1.4) 171(1; *) 172(1; *) 174(2; *)
175(1; *) 176(1; 0.5) 177(10; 1.8) 178(18; 4.5) 179(17; 3.6)
180(25; 5.9) 181(21; 4.5) 186(2; *) 189(1; *) 194(1; *)
197(23; 4.1) 198(10; 2.3) 199(59; 7.3) 200(83; 17.7) 201(10; 2.3)
202(14; 1.8) 203(3; 0.5) 204(14; 2.3) 205(3; 0.5) 207(15; 2.3)
208(4; 0.9) 209(33; 4.5) 210(10; 1.4) 211(10; 2.3) 212(57; 9.1)

Scophthalmus aquosus--Cont.

213(34; 6.8)	214(17; 3.6)	215(128; 19.1)	216(4; 0.9)	225(1; *)
226(10; 2.7)	227(10; 1.8)	228(9; 1.8)	229(2; *)	230(7; 2.3)
231(3; 0.5)	232(19; 2.7)	233(70; 11.8)	234(77; 18.1)	235(53; 10.0)
236(54; 11.8)	237(2; *)	238(1; *)	240(1; *)	242(37; 9.1)
243(3; *)	251(3; *)	253(1; *)	254(6; 1.4)	256(52; 5.9)
257(25; 2.3)	258(1; *)	259(4; *)	260(75; 5.9)	261(52; 8.2)
262(356; 58.5)	263(49; 5.4)	264(29; 13.2)	265(33; 7.3)	266(9; 1.4)
267(1; *)	268(6; 0.9)	270(12; 2.3)	271(7; 1.4)	272(150; 22.7)
273(21; 3.2)	274(33; 6.8)	275(75; 9.5)	276(44; 8.6)	277(45; 10.4)
278(22; 3.6)	279(36; 6.8)	280(4; 0.5)	281(7; 1.8)	293(108; 20.4)
294(57; 10.0)	295(118; 20.9)	297(21; 4.1)	298(59; 9.1)	299(17; 2.3)
300(9; 0.5)	301(1; *)	303(1; *)	304(1; *)	305(1; *)
306(5; *)	307(2; 0.5)	308(2; *)	309(3; *)	310(1; *)
311(12; 1.8)	312(2; *)	314(1; *)	315(2; *)	316(41; 3.6)
317(7; *)	318(71; 9.1)	319(95; 9.5)	320(70; 9.1)	321(151; 21.3)
322(178; 20.4)	323(240; 20.0)	324(54; 12.7)	325(103; 21.8)	326(13; 2.3)
327(39; 5.0)	328(5; 1.4)	329(6; 0.9)	330(62; 12.7)	331(62; 9.1)
332(115; 21.8)	333(109; 18.6)	334(36; 33.1)	335(4; 0.9)	341(53; 10.0)
342(12; 4.1)	343(1; *)	351(1; *)	352(4; 0.5)	353(53; 10.9)
354(57; 10.9)	356(59; 7.3)	357(52; 10.4)	359(1; *)	360(1; 0.5)
375(1; *)	383(1; *)	386(29; 1.8)	387(14; 1.4)	388(3; 0.5)
389(13; 1.8)	390(14; 4.5)	391(62; 12.2)	392(64; 10.4)	393(51; 7.7)
394(55; 8.6)	395(46; 5.0)	396(13; 1.8)	397(26; 4.1)	398(53; 12.2)
399(36; 5.0)	400(25; 6.8)	401(3; 0.9)	402(5; 0.9)	403(7; 0.9)
404(1; *)	405(24; 4.5)	406(39; 8.6)	407(22; 5.0)	409(2; 0.5)
415(8; 2.7)	423(10; 2.3)	425(59; 13.6)	426(45; 10.9)	427(39; 10.4)
428(40; 11.8)	429(13; 3.6)	430(18; 3.6)	431(47; 10.0)	432(10; 1.8)
433(6; 1.8)	434(27; 7.3)	435(39; 7.7)	436(9; 1.8)	437(2; *)
438(42; 9.1)	443(16; 2.7)	444(5; 1.8)	445(15; 3.2)	446(5; 1.4)
454(5; 1.4)	455(6; 1.8)	459(35; 3.2)	460(19; 7.7)	461(22; 5.9)
462(22; 4.5)	463(4; *)	464(4; 0.9)	465(1; *)	466(13; 3.2)
467(14; 4.1)	470(17; 3.6)	471(6; 0.9)	472(10; 2.3)	473(5; 0.9)
474(23; 6.8)	475(8; 1.8)	477(4; 0.9)	478(6; 1.4)	479(14; 2.7)
480(9; 2.3)	481(3; 0.9)	482(6; 1.4)	484(3; 1.4)	485(2; 0.5)
487(2; 0.5)	490(3; *)	498(1; *)	500(1; *)	501(3; 0.5)
502(58; 14.5)	503(46; 13.2)	504(63; 15.4)	505(53; 9.5)	506(20; 5.0)
507(75; 15.9)	508(26; 7.3)	509(49; 15.0)	510(30; 8.6)	511(89; 22.2)
512(6; 1.8)	513(12; 2.7)	515(5; 1.8)	516(2; 0.5)	517(21; 6.4)
518(29; 8.3)	519(9; 2.3)	520(2; 0.5)	521(30; 5.9)	522(1; *)
523(32; 6.4)	524(10; 3.2)	525(4; 0.9)	526(9; 2.7)	527(4; 1.4)
542(7; 1.8)	543(2; 0.5)	544(2; 0.5)	545(4; 1.4)	546(12; 2.7)
553(1; *)	554(6; 0.9)	556(5; 0.5)	557(1; *)	559(2; 0.5)
560(9; 1.4)	561(3; 0.9)	562(22; 4.5)	563(8; 1.4)	564(1; *)
565(6; 0.9)	566(4; 0.9)	567(7; 1.8)	568(64; 4.5)	569(98; 24.0)
570(268; 60.3)	571(12; 2.3)	572(55; 12.7)	573(23; 6.4)	574(19; 3.6)
575(4; 1.4)	577(38; 8.2)	578(14; 3.6)	579(98; 20.4)	580(91; 21.8)
581(113; 25.9)	582(227; 53.5)	583(171; 12.2)	584(49; 12.7)	585(12; 2.7)
586(5; 1.4)	587(8; 2.7)	588(30; 7.7)	589(56; 15.0)	590(264; 32.7)
591(18; 4.5)	592(58; 14.1)	593(50; 11.3)	594(65; 15.4)	595(18; 3.6)
596(2; *)	598(1; *)	599(1; 0.5)	616(1; *)	617(8; 2.7)
618(1; *)	620(5; 1.8)	621(9; 2.3)	622(29; 7.3)	623(57; 13.6)
624(107; 24.0)	625(90; 18.1)	626(7; 2.3)	627(3; 0.5)	628(2; 0.5)
629(2; *)	634(1; *)	635(4; *)	637(36; 8.2)	638(71; 14.5)
639(385; 71.2)	640(29; 5.4)	641(18; 4.5)	642(14; 2.3)	643(107; 17.7)

Table 3.--Continued

Scophthalmus aquosus--Cont.

644(543; 67.6) 645(101; 20.4) 646(66; 15.0) 647(12; 2.7) 648(24; 5.9)
649(128; 32.7) 650(180; 38.6) 651(34; 8.2) 652(1; 0.5) 653(74; 19.5)
654(2; 0.5) 655(96; 23.1) 658(2; 0.9) 659(1; *) 660(1; *)
662(4; 0.9) 663(1; *) 683(15; 3.2) 684(15; 3.2) 685(209; 43.5)
686(15; 3.6) 687(52; 12.7) 688(106; 25.9) 689(403; 80.7) 690(778; 144.7)
691(40; 9.1) 692(4; 0.9) 693(4; 0.9) 694(13; 3.2) 695(1; *)
696(1; *) 697(3; 0.5) 699(16; 4.1) 700(207; 43.5)

PLEURONECTIDAE

Glyptocephalus cynoglossus, witch flounder

160(1; 0.9) 163(5; 0.5) 164(8; 0.5) 206(6; 0.9) 228(2; 0.9)
286(43; 5.0) 296(3; 1.4) 330(1; 0.5) 337(1; *) 339(1; 0.5)
340(1; 0.5) 346(229; 122.5) 396(1; 0.5) 416(1; 0.5) 417(36; 13.2)
420(28; 5.0) 421(1; *) 437(1; 1.4) 441(1; *) 458(3; 0.5)
522(1; *) 531(8; 1.4) 535(1; *) 537(5; 0.9) 601(6; 2.7)
604(1; *) 605(1; *) 609(1; *) 612(35; 3.2) 613(2; 0.5)
616(1; 0.5) 619(2; 0.9) 662(1; 0.5) 668(1; 0.9) 669(2; *)
671(1; *) 672(1; *) 673(5; 1.4) 674(2; 0.9) 677(1; *)

Limanda ferruginea, yellowtail flounder

27(1; 0.5) 31(10; 3.2) 41(1; 0.5) 53(1; *) 55(3; *)
57(4; 0.9) 58(14; 0.9) 87(4; *) 93(1; *) 94(4; 0.9)
96(1; 0.5) 104(1; *) 105(7; 0.5) 106(4; 0.5) 113(1; *)
114(2; *) 115(2; *) 141(1; *) 152(34; 2.7) 153(20; 1.4)
155(1; *) 156(3; 0.5) 177(1; *) 178(1; *) 202(1; *)
217(1; 0.5) 223(6; *) 224(101; 9.1) 225(207; 17.2) 226(44; 7.3)
227(2; *) 230(1; *) 260(20; *) 261(1; *) 264(8; *)
280(4; 0.9) 281(6; 0.9) 282(6; 1.8) 283(13; 1.8) 292(7; 3.2)
293(1; *) 321(5; *) 322(1; *) 324(1; 0.5) 327(1; *)
329(3; 1.4) 330(8; 3.2) 331(2; 0.5) 335(10; 3.2) 336(3; 0.9)
337(2; 0.5) 338(8; 0.9) 339(1; 0.5) 341(3; 0.9) 342(7; 3.2)
343(2; 0.5) 351(1; *) 353(2; 0.5) 354(1; *) 357(8; 2.3)
391(1; *) 392(15; 7.3) 393(19; 5.9) 394(8; 1.8) 395(21; 7.7)
396(39; 14.5) 397(41; 12.7) 398(44; 9.5) 399(17; 5.0) 400(7; 2.7)
402(2; 0.5) 403(48; 18.1) 404(1; 0.5) 405(41; 15.0) 406(81; 22.7)
407(23; 6.8) 408(2; 0.9) 409(9; 4.1) 415(3; 0.9) 421(1; 0.5)
423(8; 3.2) 425(7; 2.7) 426(1; 0.5) 427(5; 2.3) 428(8; 4.5)
429(5; 2.3) 430(22; 10.0) 431(14; 6.8) 432(1; 0.5) 433(37; 14.5)
434(25; 8.6) 435(90; 32.7) 436(17; 6.8) 437(78; 30.8) 438(11; 4.1)
443(8; 2.3) 444(6; 2.3) 445(2; 0.9) 446(4; 1.4) 447(3; 1.4)
452(10; 5.4) 453(5; 2.3) 454(4; 1.4) 460(1; 0.5) 461(1; *)
462(2; 1.4) 463(27; 10.9) 464(15; 4.1) 465(1; *) 467(3; 0.9)
470(1; 0.5) 471(1; *) 472(1; 0.5) 476(1; *) 477(7; 2.3)
478(7; 2.7) 479(41; 11.3) 480(2; 0.5) 481(5; 2.3) 485(1; 0.5)
501(3; *) 502(2; 0.9) 505(12; 1.8) 506(26; 8.6) 507(26; 7.7)
508(32; 11.3) 509(5; 1.8) 510(9; 3.2) 511(2; 0.5) 512(18; 6.8)
513(24; 6.4) 515(13; 3.2) 516(10; 3.2) 517(1; 0.9) 519(1; 0.5)
520(2; 1.4) 521(4; 1.4) 522(24; 8.2) 523(18; 4.5) 524(3; 1.4)
525(1; *) 526(20; 8.6) 527(13; 3.2) 529(4; 1.8) 542(1; *)
543(2; 0.9) 544(14; 5.4) 545(6; 2.3) 546(26; 7.3) 547(1; *)
572(15; 3.6) 573(4; 0.5) 574(20; 2.3) 575(26; 6.8) 576(2; 0.9)
577(12; 3.6) 578(3; 1.4) 582(2; *) 583(1; 0.5) 584(8; 2.3)
585(189; 28.6) 586(67; 12.2) 587(54; 17.2) 588(19; 6.4) 590(1; 0.5)

Table 3.--Continued

Limanda ferruginea--Cont.
591(3; 0.9) 594(23; 8.2) 595(51; 14.5) 596(24; 6.4) 597(40; 11.3)
598(27; 9.5) 599(32; 11.3) 600(14; 5.0) 601(47; 22.2) 602(3; 1.4)
608(4; 1.8) 616(3; 1.4) 617(2; 0.9) 618(5; 1.8) 619(9; 4.1)
620(8; 2.3) 621(5; 1.4) 622(2; 0.5) 627(17; 6.8) 641(2; *)
642(6; *) 643(1; *) 652(33; 10.0) 653(1; 0.5) 654(34; 12.2)
655(1; 0.5) 656(16; 11.8) 657(7; 3.2) 658(64; 6.4) 659(19; 3.2)
660(3; 0.5) 661(3; *) 662(2; 0.9) 665(8; 4.1) 666(11; 4.1)
667(3; 1.4) 668(1; *) 681(1; 0.5) 687(2; *) 694(1; *)
695(7; *) 696(3; *) 697(1; *) 698(1; *)

Pseudopleuronectes americanus, winter flounder
3(3; *) 4(3; 0.5) 6(1; *) 9(2; 0.5) 10(25; 3.2)
11(1; *) 12(1; *) 16(11; 1.4) 17(21; 2.3) 18(6; 0.5)
19(12; 1.4) 20(9; 1.8) 21(49; 9.5) 22(5; 1.4) 23(5; 1.4)
24(9; 2.3) 25(23; 5.9) 26(2; 0.5) 27(24; 6.4) 28(4; 1.4)
29(1; *) 30(8; 2.7) 31(1; 0.5) 41(1; 0.5) 42(1; 0.5)
43(8; 2.7) 44(25; 9.1) 45(10; 2.7) 46(5; 0.9) 47(5; 1.4)
48(4; 0.9) 50(3; 0.9) 51(5; 1.4) 52(35; 10.9) 53(122; 34.9)
55(7; 2.7) 56(9; 4.5) 57(10; 4.5) 59(7; 3.2) 60(4; 0.5)
61(1; *) 62(15; 0.9) 63(13; 0.9) 66(1; *) 67(3; *)
68(7; *) 69(4; 0.5) 70(25; 2.3) 71(2; *) 72(2; *)
73(1; *) 77(3; *) 78(3; *) 79(13; 1.4) 80(4; 1.4)
81(9; 3.2) 83(2; 0.5) 85(10; 2.3) 86(6; 0.9) 87(18; 4.5)
90(3; 0.5) 93(1; 0.5) 94(7; 2.3) 105(7; 2.7) 106(7; 2.3)
107(3; 0.9) 112(7; 1.8) 115(14; 1.8) 116(3; 0.5) 119(1; *)
135(1; *) 136(3; 0.5) 142(3; 0.5) 146(1; *) 149(1; *)
152(7; 1.8) 153(2; 0.5) 154(5; 1.4) 155(3; 0.9) 156(2; 0.5)
157(1; 0.5) 168(1; *) 171(1; *) 175(3; 0.5) 177(1; *)
178(2; *) 179(2; *) 180(2; 0.5) 183(1; *) 184(4; 0.5)
185(5; 0.5) 186(2; *) 187(4; 0.5) 188(3; *) 189(1; *)
190(3; *) 192(14; 1.4) 193(2; *) 195(8; 0.5) 196(16; 0.9)
199(1; *) 200(1; *) 211(1; *) 226(1; *) 227(4; 1.8)
228(5; 1.4) 229(3; 0.5) 230(5; 1.4) 231(1; *) 236(3; 0.5)
237(2; *) 238(7; 0.5) 239(3; *) 240(3; *) 241(4; 0.5)
242(26; 4.1) 243(35; 5.0) 244(44; 5.0) 245(2; 0.5) 246(57; 4.5)
247(7; 0.9) 248(16; 0.9) 249(27; 2.7) 250(10; 0.9) 254(1; *)
256(12; 1.4) 257(43; 3.2) 258(80; 9.5) 259(8; 2.3) 260(9; 0.5)
262(2; *) 263(3; *) 266(4; 0.5) 267(2; 0.9) 268(2; 0.5)
269(1; *) 271(3; 0.9) 272(2; 0.5) 273(1; 0.5) 274(1; *)
277(3; 0.5) 280(3; 0.9) 281(1; *) 282(2; 0.9) 283(1; *)
292(3; 1.4) 293(2; 0.5) 295(9; 1.8) 296(2; *) 298(18; 6.8)
299(14; 1.4) 300(14; *) 301(11; 0.9) 302(7; *) 305(2; *)
306(2; *) 307(8; 0.9) 308(13; 2.3) 309(5; 0.5) 310(27; 5.0)
311(49; 2.7) 312(32; 3.6) 313(3; 0.5) 314(39; 2.7) 315(6; 0.9)
316(49; 5.9) 317(35; 5.4) 318(85; 3.2) 319(117; 4.1) 320(122; 14.5)
321(6; 0.9) 322(3; *) 323(12; 1.8) 324(6; 2.3) 325(5; 1.4)
326(6; 1.8) 327(4; 0.9) 328(2; 0.5) 329(3; 0.9) 330(36; 3.2)
331(17; 5.4) 332(14; 3.6) 333(25; 5.9) 334(9; 10.9) 335(6; 1.8)
336(2; 0.9) 341(4; 1.4) 342(2; 0.5) 343(5; 1.8) 347(1; 0.5)
352(2; 0.9) 353(2; 0.9) 354(4; 1.4) 356(3; 0.9) 360(2; 0.5)
361(1; *) 364(3; 0.5) 371(13; 1.4) 376(1; *) 386(44; 3.2)
387(31; 1.8) 388(18; 1.4) 389(34; 4.1) 390(39; 13.2) 391(12; 2.3)
392(10; 0.5) 393(2; 0.9) 394(9; 2.3) 395(20; 5.0) 396(6; 0.9)
397(3; 0.9) 398(2; 0.5) 399(11; 3.6) 400(20; 5.4) 401(10; 3.6)

Pseudopleuronectes americanus--Cont.

402(22; 6.8) 403(13; 3.2) 404(14; 5.9) 405(27; 5.4) 426(5; 2.7)
427(4; 2.7) 428(8; 3.2) 429(3; 0.9) 431(1; 0.5) 433(1; 0.5)
434(3; 1.4) 435(2; 0.9) 437(3; 0.5) 438(2; 0.5) 439(1; *)
459(9; 1.4) 460(6; 1.8) 461(7; 1.8) 462(14; 5.9) 463(3; 0.9)
464(2; 0.5) 466(1; *) 467(1; *) 470(1; *) 471(9; 3.2)
474(2; 0.5) 479(4; 0.9) 480(5; 1.8) 482(7; 1.8) 483(1; 0.5)
484(6; 2.7) 485(3; *) 489(3; *) 491(2; 0.9) 494(1; *)
496(1; *) 500(1; *) 501(17; 8.2) 502(14; 4.5) 503(9; 1.8)
504(3; 0.9) 505(26; 5.9) 506(4; 1.4) 507(18; 3.6) 508(18; 3.6)
509(12; 2.7) 510(11; 2.7) 511(4; 0.9) 512(29; 5.0) 513(3; 0.5)
516(1; 0.5) 517(9; 2.7) 518(12; 3.6) 519(2; 0.9) 520(3; 1.8)
521(1; *) 522(5; 0.9) 527(1; 0.5) 546(7; 2.3) 547(3; 0.5)
555(2; 0.5) 557(3; 0.5) 558(3; 0.9) 559(8; 1.4) 560(8; 1.8)
561(2; 0.5) 562(9; 1.4) 563(7; 0.9) 564(9; 1.8) 565(4; 0.5)
566(4; 0.9) 567(55; 5.9) 568(13; 3.2) 569(14; 3.2) 570(53; 10.0)
571(10; 1.8) 572(19; 5.0) 573(15; 8.6) 574(2; 0.5) 575(1; 0.5)
576(2; 0.9) 577(4; 1.4) 578(2; 0.5) 579(16; 3.2) 580(9; 3.2)
581(16; 4.1) 582(10; 2.7) 583(22; 7.3) 584(9; 2.7) 586(1; 0.5)
588(15; 3.2) 589(31; 9.1) 590(22; 5.4) 591(3; 0.5) 592(12; 2.7)
593(26; 5.4) 594(68; 13.6) 595(7; 0.9) 622(2; 1.4) 623(7; 3.2)
624(10; 1.8) 625(32; 10.4) 626(10; 4.1) 628(20; 1.4) 629(9; 0.5)
630(5; *) 633(2; *) 636(15; 0.9) 637(26; 4.1) 638(26; 4.5)
639(9; 1.4) 640(2; *) 641(9; 1.4) 642(44; 8.6) 643(28; 5.0)
644(183; 17.2) 645(78; 16.3) 646(72; 15.9) 647(25; 6.4) 648(36; 8.6)
649(30; 6.4) 650(12; 3.6) 651(40; 10.9) 652(11; 1.8) 653(47; 37.2)
655(20; 5.0) 659(8; 3.6) 662(4; 2.3) 666(1; 0.5) 682(1; 0.5)
683(8; 1.8) 684(3; 0.5) 685(13; 1.4) 686(6; 2.3) 687(15; 5.0)
688(4; 0.9) 689(7; 0.5) 690(12; 2.3) 691(11; 5.4) 692(5; 2.3)
693(8; 4.5) 694(6; 2.3) 695(4; 2.3) 696(3; 0.9) 697(2; 0.9)
698(4; 0.9) 699(20; 7.7) 700(8; 2.3)

CYNOGLOSSIDAE

Symphurus plagiusa, blackcheek tonguefish
325(1; *) 539(1; *)

Symphurus sp.
36(1; *) 221(1; *) 421(1; *)

BALISTIDAE

Balistes capriscus, grey triggerfish
164(1; *)

Monacanthus hispidus, planehead filefish
35(1; *) 86(1; *) 87(1; *) 90(1; *) 113(1; *) 114(1; *)
117(2; *) 134(1; *) 140(2; *) 142(4; *) 143(1; *) 144(3; *)
145(4; *) 150(6; *) 151(2; *) 157(1; *) 163(9; *) 164(3; *)
166(1; *) 168(2; *) 173(1; *) 187(1; *) 200(2; *) 201(2; *)
202(5; *) 203(3; *) 204(1; *) 205(6; *) 206(2; *) 207(2; 0.5)
208(2; *) 210(2; *) 211(2; *) 212(11; *) 213(7; *) 214(3; *)
215(14; 0.5) 216(2; *) 227(2; *) 233(4; *) 235(4; *) 236(3; *)
260(1; *) 266(7; 0.5) 268(7; *) 269(1; *) 270(1; *) 271(1; *)
273(6; *) 274(7; *) 275(2; *) 276(8; *) 277(6; *) 279(2; *)
293(37; 1.4) 294(1; *) 295(8; *) 297(2; *) 298(1; *) 324(2; *)
325(3; *) 329(2; *) 330(1; *) 335(3; *) 342(3; *) 353(2; *)
354(19; 0.9)

Table 3.--Continued

TETRAODONTIDAE

Sphoeroides maculatus, northern puffer

35(1; *) 120(1; *) 137(1; *) 139(27; 0.5) 144(1; *) 198(12; 0.5)
199(5; *) 200(5; *) 201(8; 0.5) 202(7; *) 204(2; *) 206(1; *)
209(2; *) 212(15; *) 214(92; 2.7) 215(52; 0.5) 233(2; *) 234(8; 0.5)
236(2; *) 260(2; *) 261(1; *) 263(1; *) 264(2; *) 265(1; *)
266(2; *) 271(1; *) 272(10; *) 273(5; *) 274(1; *) 276(1; *)
294(2; *) 321(1; *) 322(1; *) 331(1; *) 332(6; *) 333(1; *)
334(2; *)

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